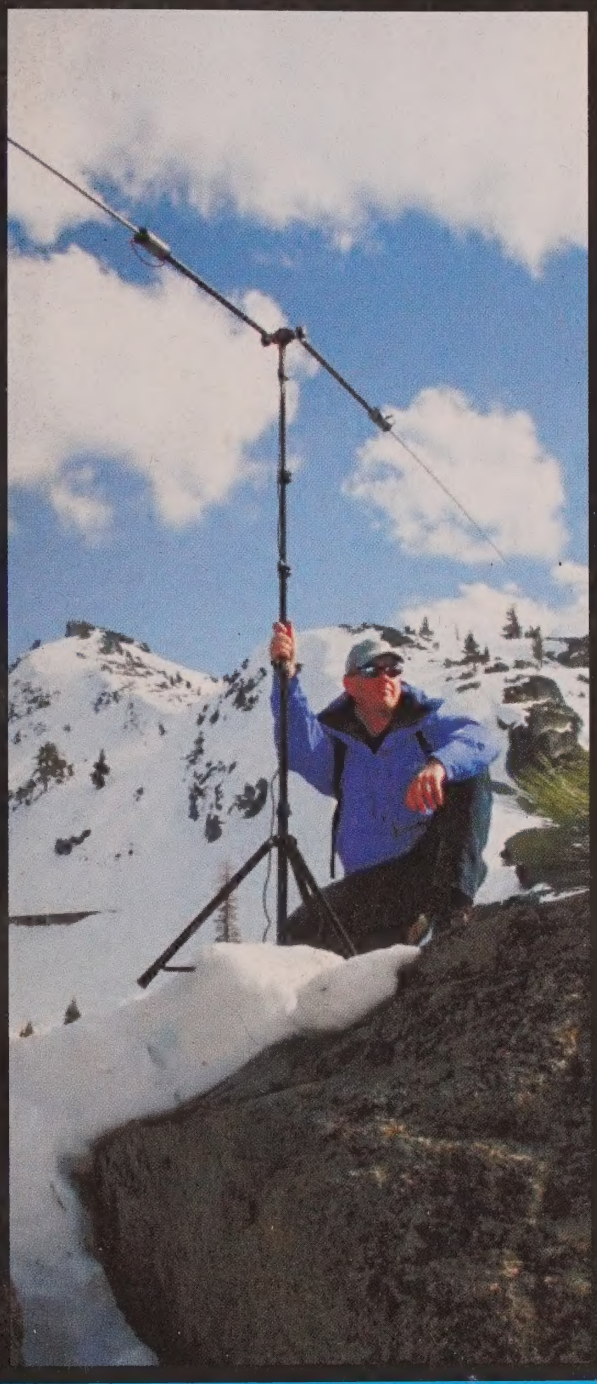

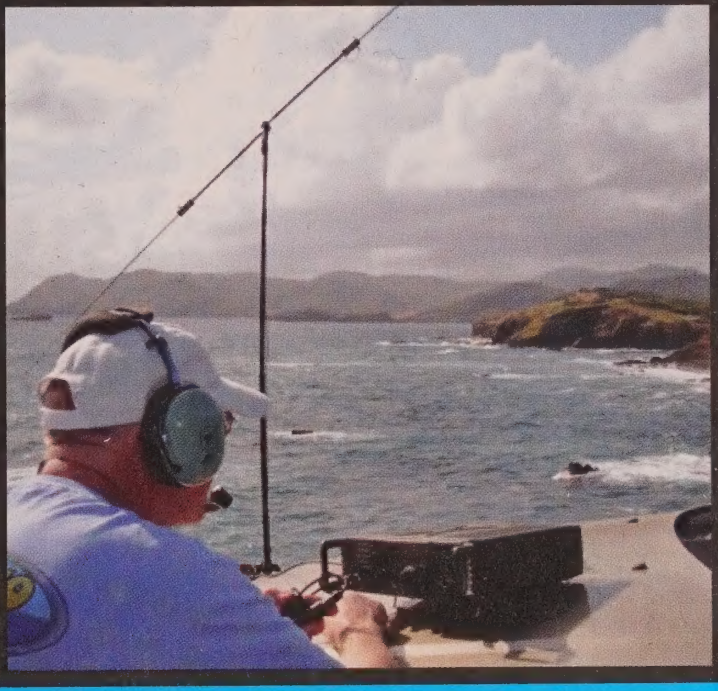

BUDDIPOLE IN THE FIELD

by **B. Scott Andersen, NE1RD**
Foreword by **Chris Drummond, W6HFP**
BUDDIPOLE, Inc.

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Buddipole™ in the Field

B. Scott Andersen, NE1RD

Buddipole™ in the Field

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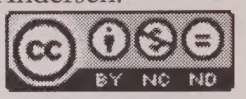

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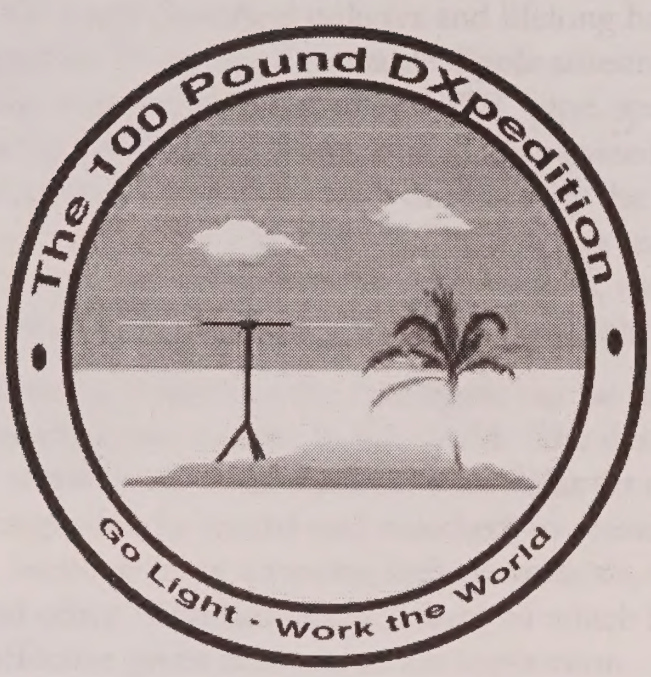


A *100 Pound DXpedition* Book

Foreword

Back in early 2000 a self-described tinkerer and lifelong ham radio enthusiast designed in his garage a rotatable dipole antenna made of common everyday components, including CPVC pipe, speaker wire, and adjustable TV whip antennas. The antenna quickly gained an online following of "hf portable ops" who were intrigued by the antenna's effectiveness, portability, and ease of use. The antenna soon became known as "the Buddipole" (short for "Budd's dipole"), named for the inventor, Budd (W3FF), who also happens to be my father.

Today, the commercial version of the Buddipole can be found on every continent, and nearly every country in the world. The design has evolved from a simple horizontal dipole to a modular set of components, designed to be mixed-and-matched, to create many other configurations. Some of these antennas include verticals, vertical beams, jpoles, Yagis, and other "Frankantennas," many of which have proven to be remarkably effective given their particular application.

One person who has been instrumental in adding to the knowledge pool of how to maximize the effectiveness of the Buddipole system is B. Scott Andersen, NE1RD. I got to know Scott on our first "100 pound DXpedition" to the Caribbean island of Montserrat in 2007. What impressed me most about him was his meticulous (some would say "ruthless") preparation ethic. Our ragtag group of operators, who for the most part had never met in person, were soon passengers on the "NE1RD express planning train," complete with weekly conference calls, equipment spreadsheets, band plans, and operating schedules. Scott aptly penned the motto for this first trip as "not rare, but well done," and the discipline paid off with the benefits having carried through to our most recent trip to St. Lucia in February 2010.

Scott applies this same type of discipline to his selection of antennas, with an emphasis on increasing performance by increasing the physical size of the antenna, creating more efficient grounding systems, and other tips and tricks that operators at all skill levels will find useful. He removes a lot of the inevitable subjectivity that is so prevalent in many antenna discussion circles, and backs up his findings with antenna modeling that confirms his theories. We're lucky that he's been willing to share his knowledge with us.

As we approach the 10th year of business at Buddipole (really, has it been 10 years?) we're as excited as we've ever been about the potential of this unique portable antenna system, and the new ideas and products

that are coming down the road. We are continuing to improve each area of the business, including providing more types of assistance such as online video tutorials (www.youtube.com/buddipole), regional Buddipole gatherings, and support documents such as this book. And, we are particularly blessed by a large following of Buddipole users (nearly 5,000 now just on our online group called "the B.U.G.", or Buddipole User's Group) who continue to be our best source for new ideas and inspiration.

Enjoy the book and get ready for some great operating in sunspot cycle 24 and beyond!

Chris Drummond
President
Buddipole, Inc.

March 2010

Join the B.U.G. (Buddipole User's Group)

www.groups.yahoo.com/group/buddipole

Preface

When the term *ham radio station* is mentioned, most picture an old man sitting among a ramble of dusty gray boxes, glowing and warming his shack on a cold winter's evening. Outside would be a triangular tower that had long ago lost its sheen, punctuated with sagging spires sprouting from the long booms reaching out from its apex.

The above might have been the archetypical shack once, but it is not so today. Amateur radio has become a more dynamic and varied pursuit. This rapid change in the hobby has been made possible by a revolution in electronic, computer, and energy technologies that have made equipment smaller, more energy efficient, more powerful, more versatile, more reliable, and more portable. All band, all mode transceivers delivering 100 watts of power now fit comfortably in the palm of one's hand. Computer technology driving digital signal processing (DSP) filtering and digital data modes such as PSK-31 have made it possible for operators to dig out weak signals more than ever before, and to transmit and receive digital data effectively with a minimum of power. Solar and battery technology leaps have made it possible for HF stations to operate portably for hours or days at a time from remote locations. We have come a long way from the old man and his gray boxes!

Where our hypothetical old man still has the advantage, though, is in his antenna system. His tower with its Yagi is formidable. Transceivers have shrunk. Power requirements have shrunk. Energy densities of batteries and efficiencies of solar cells have increased, but antennas cannot shrink without affecting their performance. The physical laws for antennas are unbending. One cannot negotiate with nature.

What one can do is make intelligent tradeoffs in their antenna designs and construct their systems from high-quality materials that can withstand the demands of their environment. Optimizing such things as performance versus cost, versus weight, versus deployment time are a keystone of effective portable and temporary operation. The *Buddipole* antenna system is well suited to these needs, and it is an excellent choice for managing these optimizations.

The *Buddipole* is a flexible antenna system made of high-strength aircraft aluminum and UV-resistant polymer parts, all rugged enough for nearly any situation. These interchangeable parts are equipped with standard 3/8" x 24 threads allowing for configurations utilizing both *Buddipole* and non-*Buddipole* components.

The *Buddipole* cannot defy the laws of physics. No antenna can. But, it can provide good and quick deployment options with good tradeoffs. It also breaks down for easy transport, is light, easy to pack, easy to erect, and is versatile, covering 80m through 2m. It is also unobtrusive, a feature valued by those hampered by homeowner association (HOA) rules or other covenants. A common temporary deployment is right in one's backyard.

This book describes how to configure the *Buddipole,* and how to get the most of every inch and every ounce. Properly configured, the *Buddipole* can be one of the best antenna platforms in its class. This book will show you how to get the most that the *Buddipole* has to offer.

B. Scott Andersen, NE1RD
March 2010

A note from the author

The author has no financial connection with *Buddipole*, Inc. He is just an enthusiastic user of *Buddipole* products, and is a friend to Chris and Budd Drummond. The author has had good success using these products, and he hopes this book will help others have that same level of success.

Acknowledgements

The danger of one of these lists is that someone is always omitted, much to the chagrin of the list creator. Well, here goes: Chris (W6HFP) and Budd (W3FF) Drummond of *Buddipole,* Inc. have been extremely supportive of my *100 Pound DXpedition* ideas and the development of this book. Without them there would be no *Buddipole.* My elmer Dave Bushong (KZ1O) has been patient with my endless stream of questions that began even before licensing. The *Buddipole Users on Montserrat* (BUMs) group Chris and Budd, Mike Greenwood (KC4VG), Paul Van Dyke (KB9AVO), Tom Clarke (W4OKW), and Bob Follett (KT7L) who were patient with me during the 2007 DXpedition project. Many photographs in this book were from that trip. The *Buddies in the Caribbean* team (J6 DXpedition) Chris, Budd, Mike, and Paul from the *BUMs*, Dan Gagnon (WZ1P), Steve Galchutt (WG0AT), Guy Hamblen (N7UN), and Wey Walker (K8EAB). Special thanks go to Charlie Learoyd (K1PUB), Rich Crisafulli (AB1HD), Rick Green (W1RAG), and Allison Parent (KB1GMX) for reading early drafts of the book, and providing great guidance for moving it forward. Finally, and most importantly, to Sandy Peters, the home team, who never asked if I was "born in a barn" when I was running in-and-out of the house testing all these configurations. This could not have been done without her unflagging support. I've had great help with this effort. Any errors or omissions in this book are my fault alone.

A note on *Buddipole* product descriptions

All product information contained in this book was accurate as of its first publication. That said, *Buddipole*, Inc. regularly introduces new products and makes improvements to existing products. Some products may be replaced by new versions that do not have precise compatibility or operating characteristics as those they replaced. (This has already happened. The coils from the earliest *Buddipole* models were redesigned for later models.)

Every effort has been made to ensure the advice in this book is accurate, but changes to the *Buddipole* components may have incompatibilities with the descriptions in this text. Please visit www.buddipole.com or the Yahoo! *Buddipole User Group* to obtain the latest data on *Buddipole* products, and updates to this book.

About the Author

B. Scott Andersen, NE1RD, was born and raised in rural Illinois. He graduated from Southern Illinois University Carbondale in 1981 with a degree in Computer Science. He relocated to the Boston area thereafter.

Scott held a commercial radio license in the 1970's, but the amateur radio license would not come until 2002. Once licensed, his call sign from the Amateur Extra pool AB1BL was quickly replaced by the vanity call NE1RD. He is an avid builder, contester, and lightweight DXpeditioner. During his *100 Pound DXpeditions* he has operated from Montserrat (VP2M), St. Kitts (V4), St. John (USVI), and various other islands recognized by the RSGB IOTA program. His next adventure is to St. Thomas, USVI (KP2) in March of 2010.

Scott is a software engineer working for a company specializing in safety critical software. When he is not watching baseball, reading, or traveling, he writes and develops software for the amateur radio community. Scott resides in Acton, Massachusetts with Sandy, the woman of his dreams, to whom this book is dedicated.

www.bsandersen.com

How to use this book

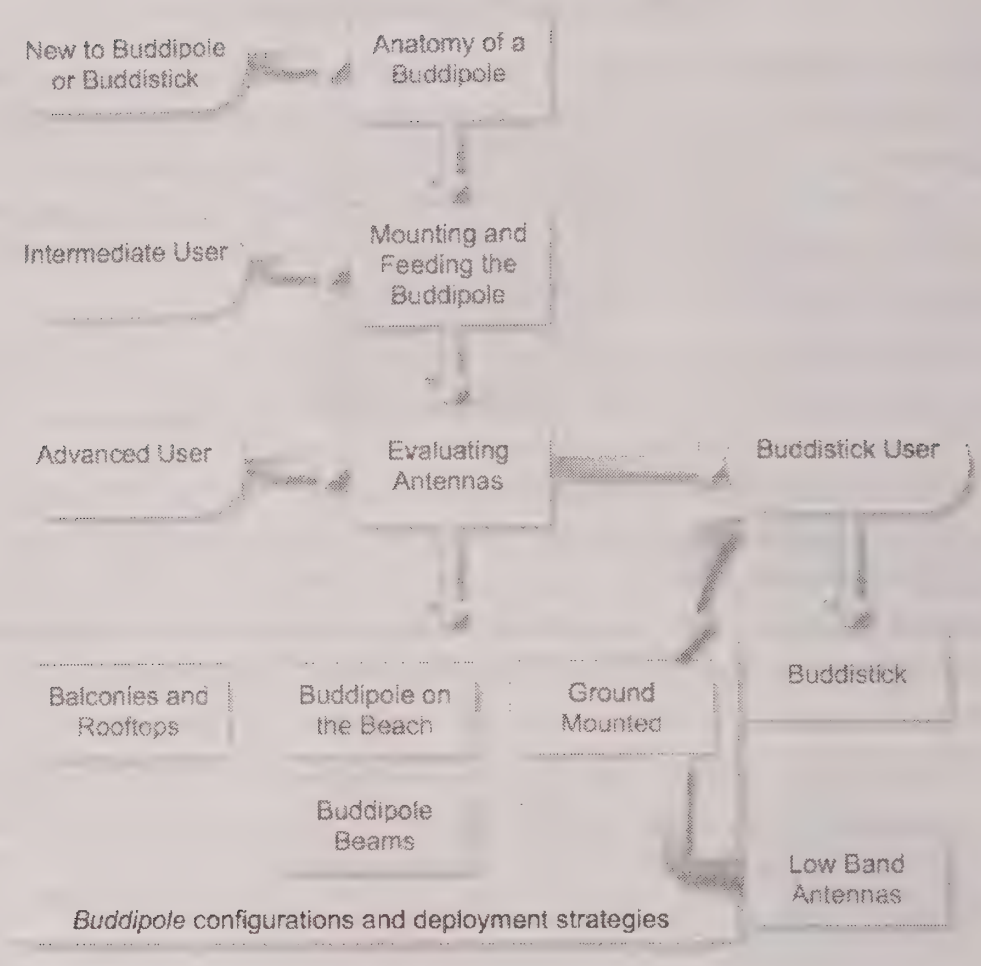
Though the *Buddipole* antenna has been around for a long time, this is the first book written for it. There is material here for enthusiasts of every background, and the book addresses the needs of several audiences. You do not need to be an antenna expert to use this book. Quite the contrary! The express purpose of the book was to help causal and serious users alike get the most from their *Buddipole* systems.

If you only wish to get ideas for how to best deploy the antenna off a deck, on a beach, or some other place, then look for the *cookbook* section within each chapter describing specific configurations, and performance expected from them. These areas are identified with a large chef's hat and a heading with *cookbook* in the title. There are lots of ideas in the book for making single element dipoles, vertical antennas, and even multi-element Yagi antennas.

If you want to know why some specific configuration for the *Buddipole* was selected for a particular purpose, look to the theory section in the front of that chapter for the rationale. Standard antenna theory, modeling, analysis, measurement, and reasoning went into the recommendations presented. The author can only hope that the decisions made are justified in the text. The reader is free to disagree, but at least you can see the process that went into the decisions.

Some suggestions in the book may not always jibe with the vast amount of *Buddipole* lore. Any product as popular as the *Buddipole* will have many ardent users, each with stories and conjectures of their awesome, never-to-be-beaten, "killer antenna designs." The purpose of this book is not to confirm or refute such claims, but to instead, using the laws of physics as our guide, select the best options for deployment using *Buddipole* components. Those with the "killer antenna designs" will have to write their own books.

The first chapter, *The Buddipole Antenna System*, provides a formal introduction to the *Buddipole*, and to the organization of the book. All readers are encouraged to start there. However, if you are the kind of reader that likes to get "right down to it" then you might find this road map helpful. (However, the author recommends skimming, not skipping, chapters.)



Finally, no one book, no matter how large and detailed, can cover all possible configurations and options for an antenna of this type. Online resources, such as the *Buddipole User Group* (BUG) pages on *Yahoo!*, are continuously updated, and knowledgeable moderators and contributors will often answer specific questions. You can also contact *Buddipole*, Inc. directly for any support needs.

NOTE: The *Buddipole* name is applied to any of several different bundles sold by *Buddipole,* Inc. When this book discusses *Buddipole* it either applies to the general idea of a *Buddipole*, or some specific configuration of it. When it is the latter, the book will be specific about which *Buddipole* model or components are under discussion.

http://www.buddipole.com

http://www.yahoo.com/group/Buddipole

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1 The *Buddipole* Antenna System

This book is about the *Buddipole*™ antenna system from *Buddipole*, Inc. What is a *Buddipole*? A *Buddipole* is an antenna for VHF and HF communications constructed from small, lightweight parts for portable and temporary use. (Note that many people use one as their permanent antenna.) There is no "one *Buddipole*" antenna; the *Buddipole* is a system that can be assembled in any number of ways to fit a particular purpose. This book will describe how to select the best *Buddipole* configuration for a variety of situations including working from a beach, hilltop, balcony, or field.

Chris Drummond, W6HFP
Buddipole President
with a *Buddipole*

The *Buddipole* antenna system can be used to construct antennas covering 7 MHz – 148 MHz in horizontal dipole, vertical dipole, vertical monopole, or other configurations. Lower bands are possible with additional components. Where full-sized antennas can be configured the *Buddipole* provides an antenna equal in performance to permanent antenna alternatives. Shortened antennas can be constructed using loading coils, and these perform surprisingly well *when deployed properly.* There are many "standard" antenna configurations, but it can also be fun and effective to create your own designs.

In this regard, the *Buddipole* is very much like the childrens' toy *erector set.* The erector set was invented by A. C. Gilbert in 1911 and manufactured by the A. C. Gilbert Company in New Haven, Connecticut until the late 1960's. (The Gabriel company of Lancaster, Pennsylvania bought the name and continued making the set into the 1980's.) The erector set included metal pieces in a wide variety of shapes and sizes, wheels, axles, pulleys, twine, motors, cogs, and all manner of mechanical contraptions. A big bag of nuts and bolts allowed children (of all ages) to build cranes, airplanes, trucks, towers, ships, and many other objects. The very best—and most fun—things to build were those not found in the scant assembly instructions and guides that came with the set; the best stuff were those things made with just the user's imagination. The genius of the erector set was that anything was possible. The *Buddipole* antenna system is very much the same! There are so many possible combinations and configurations for the *Buddipole* that no one book could cover them

all—though this book will cover many of them. And, like the erector set, the best configuration may be the ones you devise.

The author and Budd Drummond (W3FF) inventor of the original *Buddipole* operating from a field on the island of Montserrat

So, what can you do with a *Buddipole?* The list is endless, but here are a few ideas:

- Operate from a picnic table
- Take a radio on vacation
- Operate from your condo or apartment as an indoor or deck antenna
- Operate from a hilltop
- Operate from a ship or boat
- Field Day
- Emergency communication
- Contesting from a remote location
- DXpeditions
- Use it for making antenna measurements of your other antennas

The list of possible uses could fill a book! If you operate an HF or VHF radio and could use an antenna system that is extremely flexible in its configuration, deploys quickly, is rugged, portable, lightweight, and very well supported by its manufacturer and user community, then you should consider *Buddipole.*

There is a story to be told here, and this book is organized such that the story is told in order. The reader is always free to skip ahead (or back), but below is an outline of the general progression the book offers.

1 The Buddipole Antenna System

This first chapter talks about the *Buddipole* product and the outline of this book.

2 Anatomy of a Buddipole

This chapter discusses each of the *Buddipole* product models, their differences, and optional accessories available from the company store. The options enhance the capabilities of the antenna, and create new options for deployment. The company is always developing new products. Check the *Buddipole* web site for new offerings.

3 Mounting and Feeding a Buddipole

This chapter discusses the basics of how to get the *Buddipole* mounted, erected, and fed.

4 Evaluating Antennas

This chapter is one of the three theory chapters in the book (along with the first portions of the chapters *Balconies and rooftops* and *Ground Mounted Verticals*). It begins by discussing how large dynamic power differences can be and how large an S-unit really is. Far field patterns of antenna radiation are discussed. The concepts explored in this chapter are used throughout the book.

5 Balconies and Rooftops

This is the first of the *cookbook* chapters that describe how to construct and deploy *Buddipole* antennas for balconies and rooftops. Each of these chapters assumes a familiarity with the *Buddipole* system (from *Anatomy of a Buddipole*), and strategies for getting the antenna in the clear and fed properly (from *Mounting and Feeding a Buddipole*). The text relies on far field antenna modeling plots to illustrate the particulars of antenna performance. It is assumed that the materials in *Evaluating Antennas* are understood. As with each of the *cookbook* chapters, there is a discussion in the front of the chapter, and a *cookbook* section in the rear. While one could skip directly to the *cookbook*, there is significant benefit to understanding why particular configurations or deployment heights are recommended.

6 Ground Mounted Verticals

One of the most common deployments can also be one of the most challenging. This chapter shows how to create the best *Buddipole* configurations for deployment over open terrain. The short answer is vertical, but the theory section of the chapter explains why and how best to build, setup, and use the *Buddipole* as a ground mounted antenna. The theory section discusses the problems associated with shortened verticals such as low radiation resistance, low feedpoint impedance, and small 2:1 SWR bandwidth.

7 Buddipole on the Beach

Beaches bordering saltwater provide a unique opportunity for portable antennas like the *Buddipole*. This chapter discusses beach antennas and the effects of ground.

8 The Buddistick

The *Buddistick* is a family of products sold by *Buddipole*, Inc. that can be used to make verticals and other simple designs. A *Buddistick* is roughly half a *Buddipole*, equipped with two 11 inch arms, one coil, and a radial wire for constructing a vertical antenna. It is extremely lightweight and handy for quick deployments.

9 Buddipole Beams

The basic *Buddipole* systems come with enough parts to make single element antennas. Additional parts may be purchased from the *Buddipole*, Inc. accessory store enabling the construction of compact Yagi antennas. These antennas are very effective for 6m, 10m, and 12m bands. This chapter identifies the parts needed, and shows how to construct small, lightweight, strong, and effective Yagi antennas with just *Buddipole* parts and accessories.

10 Low Band Antennas

A standard *Buddipole* antenna covers bands 40m through 2m. Lower bands, 60m and 80m, are possible with additional components. This chapter shows how to construct and deploy effective antennas for the lower bands.

11 Final Words

A *Final Words* chapter gives the author one last chance to add some words of advice.

A common question by operators doing portable, temporary, or deed-restricted operation is, "How can I erect an antenna in this place for these bands?" Even in tight quarters, where wire antennas or other commercial offerings cannot fit, the *Buddipole* can. In situations where the antenna must be transported to the operating location, the *Buddipole* can travel where few other antennas can, and it comes equipped with a tripod, or a shock-cord mast, or can be fastened to the top of a simple

painter's pole so it can be deployed easily. Few other commercial offerings have this flexibility.

Getting the antenna to where it is needed is one thing, but is it any good? It is easy to deploy an antenna that works "at all" but will it work well? The difference between *works at all* and *works well* can be profound. It can mean the difference between setting up an antenna and working a few stations, and erecting the proper antenna, in the proper way, at the proper height, and working the world. The author hopes you can do the latter.

The *Buddipole,* when configured and deployed properly, is an extremely effective antenna system. This book gives you all you need to know to make those important tradeoffs in configuration and deployment to get the best out of this system.

A note to *Buddistick* users

The *Buddipole* and *Buddistick* use the same type of components. The biggest differences between these two systems are:

- **The number of components.** The type and number of parts differ between the two systems. The *Buddipole* system has many more parts, and can be used to construct dipoles. The *Buddistick* has only 22 inches of accessory antenna arms (two 11 inch pieces), one coil, and one whip. It is roughly half a *Buddipole.*
- **The VersaTee.** The *Buddipole* includes the VersaTee used to mount antennas to a mast, and to accept multiple elements. The *Buddistick* has a smaller, simpler mounting plate that cannot be used on a standard *Buddipole* mast or mount. This plate has only one mounting place for a single vertical element.

Because the *Buddistick* has fewer parts than a *Buddipole* system there are fewer options available when constructing an antenna. However, just the addition of a VersaTee (to replace the *Buddistick* mounting plate), appropriate feed line, and mast make it possible to construct some of the antennas described in the chapter *Ground Mounted Verticals* since those antennas have only a single vertical component, just like a *Buddistick.* Adding a low band coil and a longer whip to the VersaTee, feed line, and mast makes it possible for *Buddistick* users to construct low band (60m/80m) antennas.

Though the *Buddistick* starts small, it can be expanded and enhanced with accessories, just like the *Buddipole.* Each *cookbook* section indicates the parts needed to construct a given antenna. If you have the parts, you can build the antenna–whether those parts came from a *Buddipole* or *Buddistick* kit.

2 Anatomy of a *Buddipole*

Budd Drummond, W3FF, is a bundle of energy as anyone who has met him will attest. In January of 2000 Budd began experimenting with antennas for portable and "walking-portable" operation. He put his design on his web page and hams everywhere began buying the RadioShack® 6 foot whips and speaker wire, and raiding Home Depot® for plumbing supplies to make the new, very lightweight, very versatile *Buddipole.*

Chris Drummond, W6HFP, Budd's son, took the idea commercial in July of 2002. W3FF Antennas soon became the *Buddipole,* Inc. we know today. Budd's original design is still at the heart of *Buddipole's* offerings, but Chris has expanded the product line to accommodate the ever-increasing demands of *Buddipole's* customers. This book will only discuss antennas and related products from the commercial side of the family. If you are a fan of Budd's, fear not. Just because *Buddipole* has gone commercial doesn't mean Budd's fingerprints aren't all over everything! Budd continues to work closely with Chris, and he is one of the company's most enthusiastic tester of any new product.

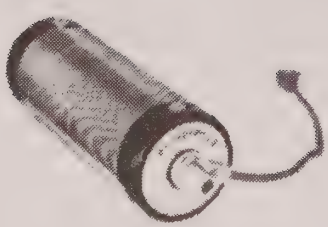
http://www.qsl.net/w3ff/

Budd Drummond's home page on QSL.NET has assembly instructions for building a do-it-yourself *Buddipole.* The Radio Shack whips are no longer available, but you can find similar whips elsewhere—including the *Buddipole* web site. Even if you are not interested in building a homebrew *Buddipole* it is interesting to read about how it all got started.

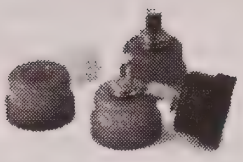
The commercial *Buddipole* (standard model) antenna is a modular system that can be deployed as a horizontal dipole, vertical dipole, or vertical monopole. It can handle up to 250 watts of power, and the basic system covers frequencies from 7–148 MHz. The basic pieces for the standard *Buddipole* are described over the next few pages.

The VersaTee™ is the heart of the *Buddipole*, and the feedpoint of the antenna. The device is constructed from an extremely rugged, UV resistant material. There are three 3/8"x24 threaded receptacles that accept *Buddipole* accessory arms, whips, coils, or other industry standard antenna components with that threading. The front of the device has three taps, connecting to those three mount points, that can either fasten wire (thumb nuts screw down on the ¼" posts), or accept small banana plugs from the companion *Buddipole* feed line. Four large feed-through holes can be used to receive rope to guy the antenna. Finally, the bottom of the device receives a ½" NPT pipe thread that mates with the available 8 foot or 16 foot *Buddipole* masts. [A small adapter is also available that enables mounting on a standard painter's pole.]

The standard *Buddipole* comes with two *accessory antenna arms*. These arms are aluminum tubes that are approximately 22" long by ¾" in diameter. They have a 3/8"x24 male post on one end and a 3/8"x24 female connector on the other. The arms can mate with the VersaTee, coils (described below), whips, and each other. They are extremely lightweight and very strong.

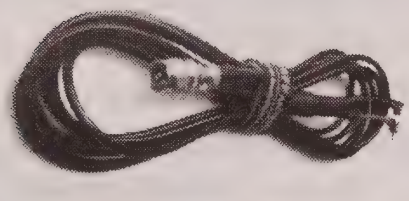


The standard *Buddipole* comes with two coils, one "red", and one "black." Like the accessory antenna arms the coils have a 3/8"x24 male post on one end, and a 3/8"x24 female connector on the other. A wander lead with a banana plug is connected to the male post that enables *tapping* the coil with the help of *coil clips* described below.

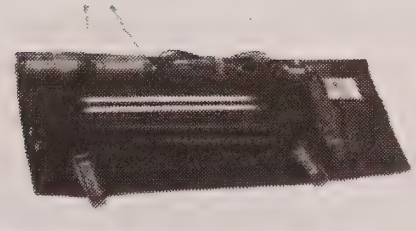


Coil clips are small stainless steel parts that are used to grip a coil wire on a single turn. The small hook of the clip loops around the coil wire, and the plastic nut screws down to pull the hook taut. The coil clip accepts the wander lead banana plug to complete the connection.

Two 5.5 foot stainless steel whips with $^{3}/_{8}$"x24 threading are included in the standard *Buddipole* package.



A 25 foot RG58A/U 50 ohm coaxial cable terminated with banana plugs on one end (to mate with the VersaTee), and a female BNC connector on the other (standard for QRP rigs) is supplied. A BNC to PL-259 adapter is included.



The kit comes packed in a nylon slipcase that can hold all the pieces in long pockets and roll them into a small bundle. The case has two long Velcro straps that hold the roll tight.

The nylon roll slipcase slips into a black thermoplastic case for storage and travel.

The standard *Buddipole* does not come with a mast. The easiest solution to getting the *Buddipole* in the air is to purchase the *Center Tee to Painter's Pole Adapter* from the *Buddipole,* Inc. accessories page. The small Delrin® single piece adapter screws on to a painter's pole Acme threads and presents a ½" pipe thread compatible with the bottom of the VersaTee. Painter's poles come in a variety of lengths. Poles in the 12-16 foot lengths are common and inexpensive.

Painter Pole Adapter

All these pieces come together to construct an antenna. Let's construct a 10m horizontal dipole to see how the process works. Using the formula 234/f = L, each length (L) of a leg for a 10m dipole should be approximately 234/28.3 = 8.27 feet, or about 8 feet 3 inches. A combination of whips, accessory antenna arms (or just "arms" for short), and possibly coils will be used to construct an antenna with these dimensions. The general strategy for constructing any *Buddipole* antenna is to create full-sized elements where possible, and to use coils to add loading where necessary.

The VersaTee is the center of the dipole and provides a place for the feedpoint to accept the coax. Begin by locating the VersaTee in the *Buddipole* kit. The VersaTee has three $^{3}/_{8}$"x24 taps that can accept arms or other antenna elements. A dipole uses two of these, the left (red) side and the right (black) side. The top tap is not used.

Orient the VersaTee so that the label faces you. Begin by screwing in an arm into the right side (black) of the VersaTee. **Do not over-tighten! *Buddipole* components should only be assembled to be "finger tight"; never use tools to tighten *Buddipole* components.** The length of our radiator is now just under two feet (22 inches). According to our calculations, we need an additional 6 feet 5 inches of radiator (or equivalent loading) to complete this antenna element.

The standard whip fully extended is only 5 feet 6 inches in length so without a coil the element will be too short. Locate the black coil and gently screw it into the end of the arm. It is good practice to ensure the nut holding the wander lead is tight before affixing the coil to the arm. Again, do not over-tighten. It is best to leave a small gap between the end of the arm and the nut holding the wander lead.

With the whip collapsed, screw the whip into the end of the black coil using minimum force. Turn until the whip is snug against the coil but do not over-tighten. This completes the construction of one element. Repeat the steps for the left side (red) by adding an arm, red coil, and whip.

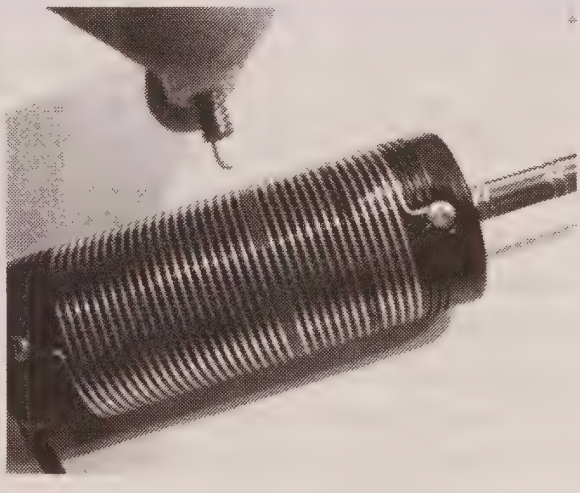
The last steps are to tap each coil at the appropriate point, and to extend the whips to the proper length. The antenna system comes with a tuning guide table similar to the one shown in Table 1. Refer to it now.

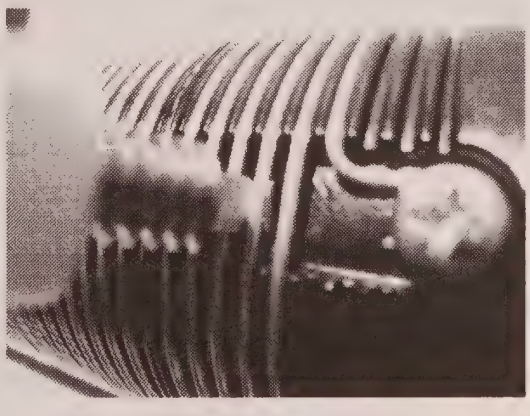
BASIC DIPOLE TUNING						
	RED SIDE COIL			BLACK SIDE COIL		
40 METERS	Yes	5.5 - 6	No	Yes	5 - 5.5	No
30 METERS	Yes	6	23	Yes	5 - 5.3	20
20 METERS	Yes	4.5	Green 10	Yes	6	Blue ½
17 METERS	Yes	5	Green 10	Yes	5.3	Black 6
15 METERS	Yes	6	Red 3	Yes	6	Black 6
12 METERS	Yes	6	2	Yes	6	4
10 METERS	Yes	5	2	Yes	6	2
6 METERS	Whips only (no coils, no arms) - 4.5 Sections out each side					
2 METERS	Whips only (no coils, no arms) 1 section - 2" (total 15") each side					

Table 1 Tuning guide for a standard *Buddipole* for 2 through 40 meters

The guidance for 10 meters is to use both the red and black coils, tapping both coils at the second turn. The red-side whip should be extended five whip sections; the black-side whip should have all six sections extended.

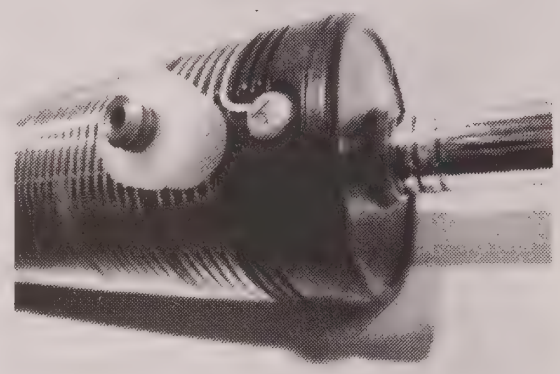
The *Buddipole* antenna system has a clever mechanism for tapping coils. Small *coil clips* are used to hook one of the turns of wire on the coil. The hook extends below a hollow threaded rod that accepts a plastic knurled nut. To tap a coil, loosen the plastic nut on the coil clip until it is very near the end of its travel, or remove the nut completely. Carefully insert the hook into the turns of wire such that the blade of the hook is away from the whip (as shown). You may need to lay the coil clip along the turns of the coil to get the end snapped in between two turns. Using the chart in Table 1, insert the coil clip hook at the appropriate turn in the coil. For the 10m coil tap, use the second turn as shown.





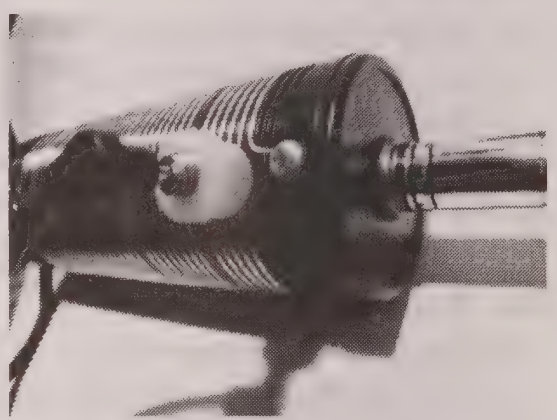
Count coil turns from the <u>whip side</u> of the coil beginning with the first full wire below the screw. Once the coil tap has hooked the

proper turn of the wire, orient the coil clip vertically (perpendicular to the coil) and carefully tighten the plastic nut. Be very careful! Do not over-tighten. The nut should be snug, but no more. Do not pull or stretch the coil wire beneath by over-tightening. The coil clip is quite strong and the plastic nut provides significant mechanical advantage. If you were to crank down on it, you could pull the coil wire off its form!



Once the coil clip is in place, take the wander lead and gently insert its banana plug into the hole of the coil clip.

Repeat this procedure for the red coil observing the tap number from Table 1 (also tap 2).



Though both coils have a large number of turns on them, it is possible to use as many, or as few, as are necessary. Further, the coils are marked with color codes on particular turns to ease tap selection for some of the supported bands. The black coil has a black stripe and a blue stripe; the red coil has a red stripe and a green stripe. The tuning guide calls out these turns as *Green 10*, *Blue 15*, *Red 4*, and *Black 6*. It is much easier to spot a stripe on the coil than to count turns. For most bands, these stripes are considerable time savers.

When coils have been tapped the antenna is ready for deployment. If it is not already on a mast, affix the mast now. Extend the whips as per the tuning guide, pulling out five sections on the red-side whip, and all six sections on the left, as per the tuning guide.

Attach the feed line by inserting the banana plug on the red wire into the left (red) connector on the VersaTee, and attach the banana plug on the black wire to the right (black) connector. Use the supplied Velcro strap to hold the feed line to the mast for strain relief. (The next chapter, *Mounting and Feeding the Buddipole,* covers these activities in more detail.)

The antenna is now ready to be deployed. Raise the mast to put the antenna at its proper height. The SWR graph as measured by an antenna

analyzer is shown in Figure 1. In this case, the 10 meter dipole antenna was deployed at 25 feet. The antenna provides a good match all across the 10 meter band with an SWR far below 2:1.

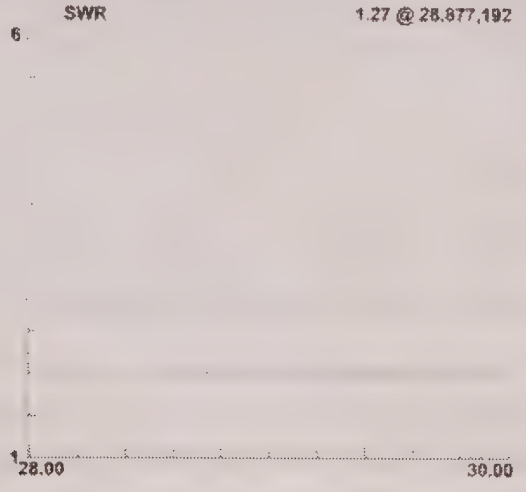


Figure 1 Measured SWR graph of 10m dipole

All *Buddipole* antenna deployments follow these same steps, or close variants. Reviewing:

1. The type of antenna to be constructed is chosen. This could be a dipole, vertical, or other configuration.
2. Components are selected from the *Buddipole* kit, and perhaps supplementary materials.
3. The elements are constructed off the VersaTee with arms (if any) first, coil if needed, and then whips—or, sometimes more conveniently for verticals, VersaTee, coil, arms, and whip.
4. Coils are tapped at the appropriate place.
5. Whips are extended to their desired length.
6. The feed line is attached, and the antenna is raised to its desired height.

Once the antenna is in place it can be used directly, or measured with an antenna analyzer or SWR meter. If the SWR is higher than expected, the whips can be adjusted (made longer or shorter) to adjust the center frequency of the antenna. In some cases, especially if the antenna is deployed with objects near by, a different coil tap for one or both coils may need to be selected. The recipes in Table 1 specify typical taps and lengths for each band. If your deployment is not "typical", then it is possible other taps and whip lengths will be required to make the antenna usable.

All of the discussions above are for the standard *Buddipole* product, the most basic product in the catalog. *Buddipole,* Inc. has a range of product offerings with the standard *Buddipole* as the basis for the product line. (*Buddistick* products are discussed separately.) The four *Buddipole* products are:

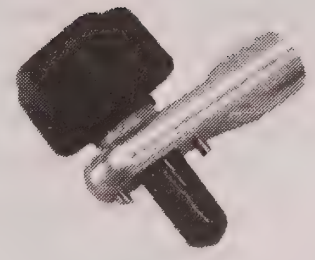
- *Buddipole*
- *Mini-Buddipole*
- *Buddipole Deluxe Package*
- *Buddipole Deluxe Package* (with long mast)

We have discussed the (standard) *Buddipole.* The *Mini-Buddipole* is identical to the standard offering except it breaks down into a smaller package. The two 22 inch arms are replaced by four 11 inch arms, and the nylon sleeve and plastic packing tube are replaced with a soft attaché style bag. Once each pair of 11 inch arms are screwed together to look like two 22 inch arms, all other details of assembly and configuration are identical to the standard *Buddipole.*

The *Mini-Buddipole* is only $25 more than the standard system (as of this writing). The superior case and smaller size make this an excellent value and well worth those few extra dollars.

Figure 2 *Mini-Buddipole* attaché bag

The big jump in the product line in both price and capability is between the *Buddipole* and *Buddiple Deluxe Package*. The deluxe package substitutes a soft yet rugged pack bag for the plastic storage case. Additionally, a tripod and 8-foot mast are included, making the kit a *system* able to stand alone (literally). A few other extras are thrown into the deluxe package including extra coil clips, a spare whip, and a Rotating Arm Kit (RAK) that provides a means of attaching items to the VersaTee at an angle.



Rotating Arm Kit element

The RAK piece is affixed to the VersaTee by a bolt with a large, soft knob. The two pins in the RAK piece mate with holes in the VersaTee so the element stays at the angle you select. The end of the RAK piece is threaded with a $^{3}/_{8}$"x24 tap, just like the VersaTee. With the RAK, antenna elements can extend from the VersaTee at angles other than horizontal and vertical. They can also be rotated in place, making adjustments to elements easier.

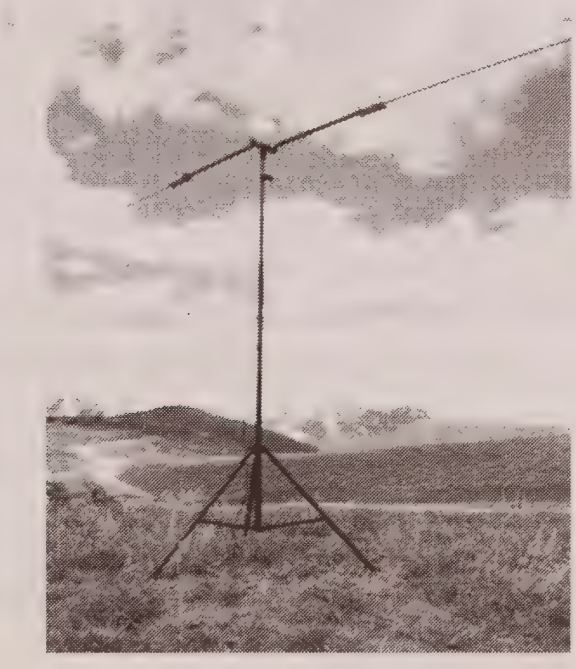


Figure 3 *Buddipole Deluxe Package* deployed

The *Buddipole Deluxe Package* can also be ordered with a 16-foot mast (instead of the 8-foot mast), Mast Guying Kit, 50-foot coax run (instead of the 25-foot run), and a longer bag (instead of the shorter bag sold with the standard length system) to accommodate the longer mast.

The Mast Guying Kit consists of three Dacron® cord lengths wound on kite winders, three metal pegs, and a 2 inch wide Velcro strap that wraps around the mast.

> **Any deployment should be guyed. Most *Buddipole* damage is incurred in the first few weeks of ownership, when an unguyed tripod and mast blow over in a sudden gust of wind. Usually, a whip is snapped, but sometimes a coil is damaged in such a fall. Don't wait until you have your first mishap. Guy your systems first time and every time!**

Most any kind of guying will work but the *Buddipole* Mast Guying Kit sold by *Buddipole*, Inc. is a convenient and effective way to get your system secured.

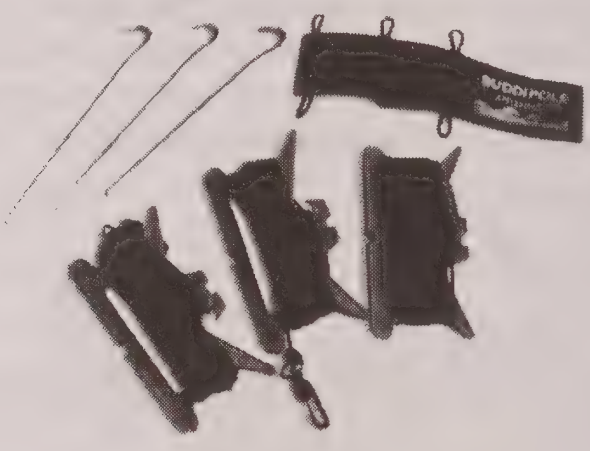


Figure 4 Mast Guying Kit

In addition to antenna systems, the *Buddipole*, Inc. web site has a large collection of accessories. And, if you don't see what you need, call the company—even items not pictured on the web site are usually available if you ask (such as converting your standard *Buddipole* to a deluxe version by buying a tripod, mast, and carry bag—the carry bag is not listed on the accessory page but it is likely Chris and company will help you upgrade anyway).

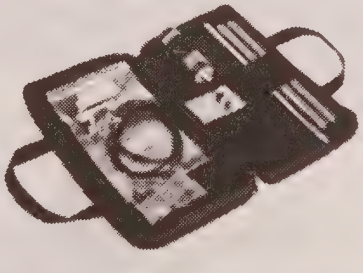
Table 2 is a matrix showing the accessories bundled with each product for the four *Buddipole* models.

Product/Components	*Buddipole* Standard Package	*Mini-Buddipole*	*Buddipole* Deluxe Package	*Buddipole* Deluxe Package (Long)
VersaTee	1	1	1	1
Accessory Arms (22 inch)	2		2	2
Accessory Arms (11 inch)		4		
Coil clips (set of 3)	1	1	2	2
Standard coil set (red/black)	1	1	1	1
Standard 5.5 foot whip	2	2	3	3
Coax 25 feet	1	1	1	
Coax 50 feet		optional		1
Nylon packing sleeve	1			
Buddipole tripod			1	1
Buddipole 8' mast			1	
Buddipole 16' mast				1
Rotating arm kit (RAK)			1	1
Guying kit				1
Plastic case	1			
Compact carry bag		1		
Padded carry bag (short)			1	
Padded carry bag (long)				1

Table 2 Comparison of components in Buddipole models

The *Buddipole* systems have enough pieces to construct dipoles or verticals. A second product line called the *Buddistick*™ contains pieces for a single element for vertical antennas only. *Buddistick* systems are less expensive than the *Buddipole* systems since they contain fewer parts. Specifically, the standard *Buddistick* system contains

- One coil
- Two 11 inch aluminum arms
- One standard whip (5.5 feet)
- Two coil clips
- Mounting plate with knob to mount plate on a standard ¼"x20 photo tripod or similar platform.
- One 31 foot radial line on a winder with ring connector
- Attaché style carry bag

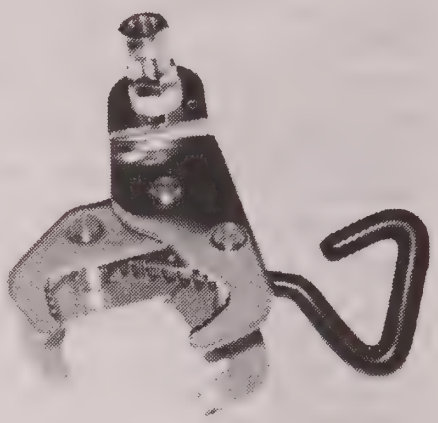


Buddistick system

The *Buddistick* is a subset of the Buddipole except for the mounting plate and radial line. The typical deployment for this antenna is tabletop or

picnic table with a clamp securing either the mounting plate or the antenna directly.

A very handy third-party mount for this antenna is sold by High Sierra. (www.hamcq.com) It is called the Jaws Antenna Mount. The mount combines a very strong clamp with a standard 3/8"x24 mount that works with all *Buddipole* and *Buddistick* components. The clamp will grip wood (2x2 or 2x4 in size), railings on hotel balconies, fence posts, or nearly any other object. The piece holding the 3/8"x24 mount rotates 90 degrees to allow the position of the antenna to be independent of the angle of the clamp. It is heavy duty (and heavy!), and holds an antenna firmly. The antenna is fed from an SO-239 connector on the bottom of the antenna mount.



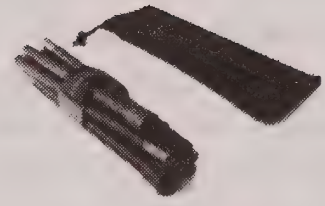
High Sierra JAWS mount

The next step up in the *Buddistick* product line is the *Buddistick Deluxe Package* which includes everything in the standard *Buddistick* pack plus an extra whip, extra coil clip, and a lightweight vertical antenna clamp for picnic table use. It is not as rugged as the High Sierra offering, but it is much easier to pack and travel, and it works fine for light duty situations such as a casual picnic table portable operation.

The *Buddipole* and *Buddistick* systems may be augmented by any of the accessories in the *Buddipole,* Inc. catalog. The next few pages highlight some of these accessories. Some, such as the *Triple Ratio Switch Balun* (TRSB) and *Low Band Coil*, will be given additional coverage later in the book.

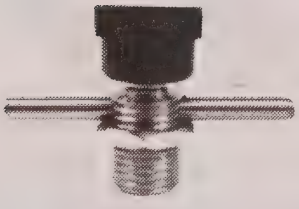
The **Triple Ratio Switch Balun** (TRSB device serves two purposes. It has a three-position switch that selects either 50:50, 50:25, or 50:12.5 ohm matching from the feed line to the antenna. The TRSB also has an isolation transformer to keep current off the outside of the coax. The TRSB was developed by Alan Biocca, WB6ZQZ, for *Buddipole*, Inc.

The **IT Adapter**, originally named for the "Inverted Tee" configuration, is an aluminum device used to create beam antennas and other structures with *Buddipole* parts.



A **shock-cord mast** is a great companion for the standard *Buddipole.* It folds small and deploys easily. The device comes in two sizes: short (8 feet) and long (11 feet). It has the mate for the VersaTee on top, and a rubber foot on the bottom.

Mini banana plug leads are the same leads that are used on *Buddipole* coils. They have other uses, too, discussed later in the book.

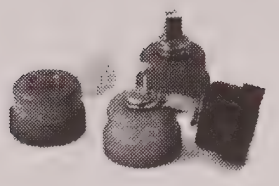


A **Counterpoise Wire Adapter** is a device with threads that fit into the standard $^{3}/_{8}$"x24 tap of the VersaTee and is used to secure radial wires.

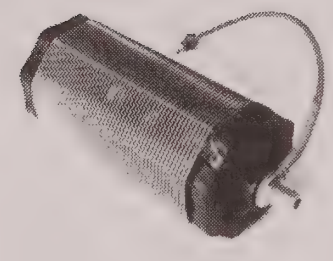
Note: the author prefers the term *radial* instead of *counterpoise* for this purpose, despite the product's name.

The **Vertical Antenna Clamp** is the same clamp used in the *Buddistick Deluxe Package.* If you get this, an extra whip, and an extra coil clip, you can convert your standard *Buddistick* into a *Buddistick Deluxe Package.*

The ***Buddistick* Tripod** is a small tripod that collapses to about 7 inches and can be used to mount a *Buddistick.*

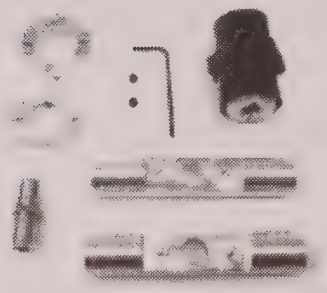


Extra coil clips are strong and brightly colored. The author has never broken one. They are, however, the most likely item in the *Buddipole* or *Buddistick* kit to be lost. Consider buying an extra set.



A **Low Band Coil** is a large coil was designed to allow the *Buddipole* to be used on the 60m and 80m bands. The standard coil clips work on this coil. A single coil can be used with a vertical configuration, or two coils can be used to replace the *Buddipole* standard coils in dipole configurations.

A **Wire Assembly** comes with 32 feet of insulated wire on a winder, terminated with a loop connector. A *Counterpoise Wire Adapter* is included. A longer version (66 feet) is also available.



A **6 Meter Yagi Kit** will enable you to construct a 2-element Yagi antenna when added to a *Buddipole Deluxe* package and a total of four whips. These parts can also be used to create 10m and 12m beams.

Shock-cord whips are made of very strong, rigid materials and come in a variety of lengths up to 12 feet.

Other standard pieces from the *Buddipole* such as the VersaTee, whips both standard length (5.5 feet) and extended length (9.5 feet), arms, and so on, are also available for separate purchase as accessories.

The strength of the *Buddipole* and *Buddistick* antenna product lines is their ability to use a wide range of interchangeable parts in wonderful combinations. The remainder of this book will show how to select from among the large number of possible configurations, and to find the right one for the job at hand.

3 Mounting and Feeding the *Buddipole*

The VersaTee is the focal point of any *Buddipole* configuration. It accepts the whips, coils, and arms for the antenna elements, supplies the feedpoint for the antenna, and provides the mounting point with its ½ inch NPT pipe thread at its base. Once an antenna configuration is selected and built, it must be mounted on a mast, and fed with the feed line. This chapter will outline strategies for erecting the antenna.

There are three general approaches to mounting the *Buddipole*.

The *Buddipole* standard tripod accommodates an 8 foot or 16 foot mast[1]. Each mast is topped with a Delrin ½" NPT adapter that matches the bottom of the VersaTee. The tripod and the 8 foot mast are part of the *Buddipole Deluxe* package, but are also available separately as accessories.

The *Buddipole* shock-cord (SC) mast is a lightweight, compact, and robust mounting solution. The mast is constructed from high-strength aluminum tubing pieces held together with a taut, stretchable cord. Each mast section end is shaped so that it locks with its adjoining section to prevent rotation. Like the other collapsible masts, the SC mast is topped with a Delrin ½" NPT adapter that matches the bottom of the VersaTee. These masts are available in two sizes: 8 feet and 11 feet. They come in a rugged, form fitting pull string bag, and wrapped in a wide Velcro strap.

The least expensive option is to top a standard painter's pole with a **painter's pole to VersaTee adapter**.

The tripod and mast offer the most convenient method for deploying the *Buddipole* quickly. If using the 8 foot mast, insert the mast into the tripod and secure with the center knob.

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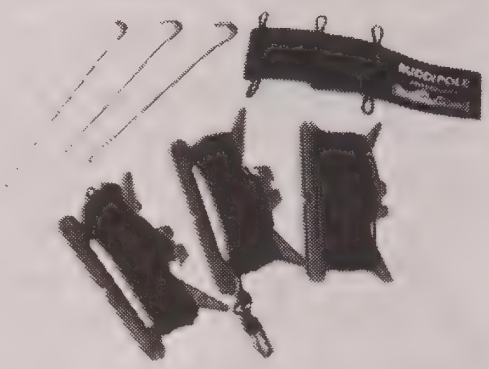
[1] *Buddipole*, Inc. has begun shipping a newer long mast and tripod. The newer mast is slighter longer than the original 16 foot mast, and it mates directly with the tripod. No separate mating tube is required. There are no significant differences between the two masts with regard to setup, configuration, or performance.

If using the 16 foot mast, insert the short tube that came with the longer mast into the tripod and secure with the center knob. The 16 foot mast attaches to the top of this short tube. Spread the tripod legs and adjust them so that the tripod is level. If using the newer long mast, mate the mast directly to the tripod.

One should guy or otherwise secure any *Buddipole* deployment. A guying kit is available as an option from *Buddipole,* Inc. The kit consists of a Velcro strap with three loops, three tent stakes, and three lengths of Dacron rope on kite winders, each terminated with a plastic hook. Wrap the strap around the mast. The three loops should be separated uniformly around the mast's circumference. Attach the plastic hooks to the loops and extend each rope out and down to the ground at a 45 degree angle. Secure with the tent pegs.

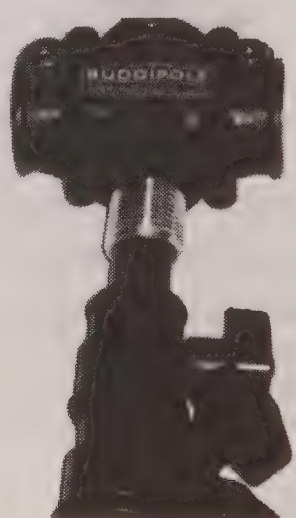


Buddipole guying kit

An alternative to guying is to hang a heavy weight from the bottom of the tripod. A cinderblock, gallon of water, or other heavy object suspended by a bungee cord works well. Alternatively, a "pet anchor" (a product sold to anchor pet leashes) can also be screwed into the ground below the tripod and used to hold it in place.

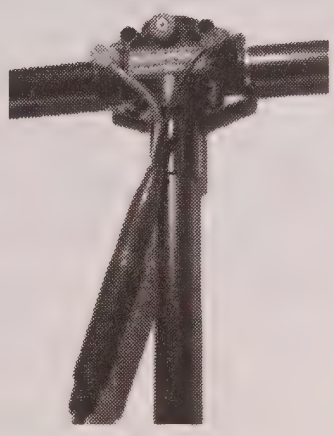
Pet anchor

It is usually easiest to begin assembling the *Buddipole* antenna configuration by affixing the VersaTee to the top of the mast and then attaching other items. If there is nothing yet attached to the VersaTee, then it can spin easily on the mast mount. However, if the VersaTee already has antenna components attached (arms, whips, etc.) then it is easier to set the VersaTee on top of the mast and rotate the mast to screw the mount into the VersaTee. In either case, the VersaTee should only be mated with the mount so that it is snug. Do not over-tighten! While it is unlikely you would damage the VersaTee (that piece is very tough!), you might dislodge the threaded piece on top of the mast.



Rotating the mast works well for the 8 foot and 16 foot standard masts on the *Buddipole* tripod. The shock-cord masts can also be rotated under the VersaTee, but since they are solid, one-piece masts (after assembly), you will need to rotate the entire mast, not just the top section as with the standard masts.

The *Buddipole* is supplied with a length of coax terminated with a BNC connector on one end and two banana plugs on the other. The banana plugs mate to the red, blue, and black mounting points on the front of the VersaTee. The red banana plug is connected to the center conductor of the coax; the black banana plug is connected to the shield of the coax. A set of ferrite beads surrounds the coax near the banana plug leads to help keep RF energy off the outside of the coax.



For a standard dipole configuration (as described in later chapters), connect the red banana plug into the red connector, and the black banana plug into the black connector. Secure the coax to the mast with the supplied Velcro strap by threading the end of the strap through the loop, tightening, then securing the strap end.

Antenna configurations that use the top tap (vertical configurations) should have the red banana plug connect to the blue connector, which is in turn connected to the top element.

An alternative to using the standard *Buddipole* coax is the *Triple Ratio Switch Balun* (TRSB). The TRSB is a plastic box with a three-position switch on its face, and a pair of BNC connectors, one on the top, and one on the bottom. The top BNC connector (closest to the switch) is the output of the TRSB; the bottom BNC connector (furthest from the switch) is the input of the TRSB.

The TRSB is superior to the standard feed line in two ways:

1. The TRSB contains a switch connected to a transformer inside the unit. The transformer provides either a 1:1, 2:1, or 4:1 ratio impedance match based on the switch setting. That is a complicated way of saying that the TRSB can match a radio that

expects to see a 50 ohm load to an antenna that presents a 50 ohm, 25 ohm, or even 12.5 ohm impedance. Vertical antennas, especially shortened vertical antennas, will present a low impedance. If there is no effort to match the impedance of such an antenna to the radio, the high SWR (caused by the impedance mismatch) will cause problems. In some cases, a radio will automatically reduce power if the SWR is over a certain level to protect its power amplifier transistors. The TRSB provides a matching capability that reduces the likelihood of this.

2. The TRSB contains a large wound toroid that is used to create an isolation transformer. The standard coax has ferrite beads on the coax to reduce current traveling from the antenna to the radio on the outside of the coax. These beads are sufficient for the higher bands (20m and up), but lower bands (30m, 40m, 60m, 80m) present currents larger than those beads can manage. The TRSB solves it nicely for all bands 10m-80m.

The TRSB is easily mounted on the *Buddipole*. Attach the small BNC to banana plug cable to the top of the TRSB. Hang the TRSB from one of the antenna arms and insert the banana plugs into the appropriate connectors on the VersaTee. For dipoles, the red banana plug should be inserted into the red hole, and the black banana plug should be connected to the black hole. For verticals, the red connector should be connected to the blue (center/top) hole, and the black banana plug should be connected to one of the other two connectors to feed the radials.

The bottom connector on the TRSB is a female BNC connector that can accept either a male BNC connector from a length of coax, or a BNC-to-SO-239 connector to enable the connection of standard coax terminated with a PL-259 connector.

The TRSB should be secured to the mast with the short Velcro strap supplied with the unit. Wrap the strap around the short BNC-to-banana plug cable, thread the end of the strap through the loop, then tighten and secure.

4 Evaluating Antennas

You have probably heard the story of the absentminded ham that powered up his radio and made several QSOs while the rig was still connected to the dummy load. The story is funny, but it is also instructive. If that same ham was asked later about his day in the shack, he might have said, "I worked everyone I heard."

Making the claim of working everyone you *heard* is not the same as working everyone you *should*. Modern transceivers are amazingly sensitive, and even mediocre or poor antennas can work "at all." If you are willing to settle for that, then you can put this book down now! What we should be striving for is to make the best antenna system we can, and deploy it the best way that we can. If you can erect a tower with stacked monoband Yagis then do so! Of course, that is not an option for most situations. If you are operating portably, temporarily, away from home, on a beach, on a hilltop, during Field Day, or any number of other situations, you will need to deploy something far smaller than that tower. It will be a compromise, and there will be tradeoffs to consider.

The *Buddipole* antenna system provides a means of deploying antennas for those situations described above. It is an extremely flexible and versatile system that gives you configuration choices that you must consider when deploying an antenna. These choices will come with tradeoffs. Making intelligent tradeoffs among antenna configurations requires a means of evaluating the choices. The main points to evaluate are:

1. Have we maximized the power output of our antenna?
2. Are we sending that power in the correct direction for our needs?

Consider the problem from the other end. What does the receiving station hear? If an improvement is made on our end, how will it be reflected on their end? If we were to double our effective power output, how will this affect what the receiver hears?

Ratios of power values are typically expressed in decibels (dB). A decibel is the ratio between two power levels computed thusly:

$$n \text{ dBs} = 10 * \log_{10} (\text{power1} / \text{power2})$$

Using this formula, one can see that the power ratio of 1.25 watts to 1 watt is 1dB. A ratio of 2 watts to 1 watt is 3 dB. The table below provides additional values for reference.

Power ratio	dB	Power ratio	dB
1.25:1	1	12.6:1	11
1.58:1	2	15.8:1	12
2:1	3	20:1	13
2.5:1	4	25.1:1	14
3.15:1	5	31.6:1	15
4:1	6	100:1	20
5:1	7	1,000:1	30
6.3:1	8	10,000:1	40
7.9:1	9	100,000:1	50
10:1	10	1,000,000:1	60

Table 3 Power ratios expressed as dB

Radios are typically equipped with an S-unit meter providing a relative expression of the power of the received signal. The meter shows this strength in a logarithmic scale (log base 10) because the range of values is very large. The difference in power levels between whole S-unit numbers (e.g., S3 and S4) is 6 dB, a factor of 4 times the power.

Consider a given station transmitting 25 watts and the receiving station registers this signal at S5. If the transmitting station were to transmit at 100 watts, assuming nothing else changed, the receiving station would now register the signal as S6 strength.

When a station gives you a signal report that you are S9 + 20 dB then you could drop your power by a factor of 100 and still register as S9 at the receiver. Every time you hear someone give a report, "you are 30 over here", consider that 1500 watts could be dropped to 1.5 watts and it would still register as S9 at the receiver!

The above analysis gives a very optimistic view of S-meter performance and accuracy. Some meters report a whole S-unit gain after only 5 dB of increase. Some meters are "more sensitive" at

An avid QRP operator will often point out that the difference between 100w and 5 watts is just a factor of 20, or 13 dB, or a little more than 2 S-units. If the QRO signal is S9, the QRP signal will be S6 to S7.

higher powers. Nevertheless, the core of the power ratio discussion holds true. The difference in power received between S0 and S9 is many tens of thousands to one.

These ratios are best illustrated by the behavior of the Northern California DX Foundation (NCDXF) *beacon* network. A beacon is a transmitter that emits its signal at regular intervals. Each NCDXF beacon transmits every three minutes, and the beacons are active on five bands: 20m, 17m, 15m, 12m and 10m. Transmissions are staggered such that within each three minute cycle all beacons for a given band have a chance to be heard. The transmission consists of a call sign at 22 WPM that identifies the beacon and its location, followed by four one second tones transmitted at decreasing power levels. The first is at 100 watts, the second is at 10 watts, the third is at 1 watt, and the fourth is at 100 milliwatts.

It is a useful exercise to tune in one of these beacons and follow the progression from one beacon to another. [Appendix D in the back of the book contains a list of the NCDXF beacons, their frequencies, locations, and timeslot within that three minute cycle that they are active.] Note how often it is easy to copy tone transmissions at the 1 watt and 100 milliwatt power levels. Examine the S-meter of your radio as the beacons go through their power progression and note how the decreasing power levels drop the S-meter by only couple of S-units with each step. It is often surprising how clear a 1 watt or 100 milliwatt signal can be from some remote point on the globe!

The NCDXF beacons intentionally lower their power in steps during each transmission cycle. Typically, operators do not repeatedly change their output power but instead choose a power level and then operate at that level for the duration. If the operator chooses 100 watts as output from the transmitter, how much will actually be radiated at the antenna? That depends on several factors, chief among them the *efficiency* of the antenna.

Antenna systems have losses that come from a variety of places. The energy delivered to the antenna that is subsequently delivered as RF radiation to the world can be compared to the total amount of energy delivered to the antenna. That percentage is the efficiency of the antenna. For example, if 100 watts were delivered to the antenna but only 50 watts were radiated as useful RF energy, then the efficiency of the antenna would be 50%.

Consider an antenna that is 1% efficient. If that antenna received 100 watts from the transmitter and only radiated 1 watt of that energy, some receivers may still hear it, just as the NCDXF beacons can be heard. Again, the question is not whether you can work everyone you hear; the question is whether your signal is reaching everyone it should.

How can an antenna system be only 1% efficient? This might sound unlikely. Unfortunately, it is quite easy to create an antenna system that is 1% efficient, or even worse. The place to begin our understanding of how this can happen is at the antenna feedpoint.

The feedpoint of an antenna is the point where the feed line is attached to the antenna. The most important characteristic of the feedpoint is its *impedance.* The general definition of impedance is "a measure of opposition to alternating current." There are three components of this opposition within an antenna system. They are:

1. **Ohmic resistance**. Antennas are made of metal and metal has resistance. When electrical current is forced through a resistor the result is a loss of power in the form of heat. Antennas are typically made of materials that have very low resistances such as copper and aluminum to minimize this problem. Steel has a relatively high resistance compared with copper (though it is physically much stronger). This is why steel antenna wire is often "copper clad" so that the outside of the wire is a low-resistance copper while the strength of the wire is that of steel.

   There are other places where pure resistances can cause losses. In a vertical antenna system, where the ground (or a radial system) is used as the "other half" of the antenna, ohmic losses can be quite large. Recall Ohm's law I=E/R (current is voltage divided by resistance). Higher resistance means less current in the circuit. Less current means less power.

2. **Radiation resistance**. Putting a signal into the environment requires work. The resistance associated with doing this work is called *radiation resistance.* Put simply, we like this one. This is what gets the job done. If the entire antennas impedance was composed of radiation resistance, then the antenna would be 100% efficient.

3. **Inductive and capacitive reactance**. Reactance is an opposition to alternating current. Reactance comes in two flavors: inductive and capacitive, both of which are measured in ohms (as is ohmic resistance). The term *resonance* is defined to be

when any inductive and capacitive reactance in the system is equal and opposite.

It is easiest to understand these concepts by examining a simple antenna[2]. An ordinary resonant 80m half-wave dipole, fed in the middle, and in *free space* (away from anything that may affect the characteristics of the antenna, especially the ground), and made of number 14 wire will have a feedpoint impedance of approximately 70 ohms. The ohmic resistance in the system will be about 2 to 3 ohms. Therefore, the radiation resistance must be 67 to 68 ohms. Since we have stated that this antenna is resonant, the sum of inductive and capacitive reactance values are zero. The efficiency can be stated as

$$\text{Efficiency}\% = \frac{\text{Radiation_resistance}}{\text{Radiation_resistance} + \textit{Losses}} x100$$

In the case of our dipole

$$\frac{67}{70} x100 = 96\%$$

A dipole in free space and properly sized (resonant) is about 96% efficient. That is tough to beat!

We have been using approximations to illustrate these concepts. There are two ways to obtain more accurate results. The first is to construct the particular antenna of interest, and use specialized equipment to obtain the desired data. There are challenges to this approach. First, some conditions, such as measuring an antenna in free space, may be very difficult or impossible to achieve. Second, creating the antennas, erecting them, and measuring them is time-consuming and the equipment is expensive.

It is helpful to make a distinction between two important concepts: (a) resonance, and (b) an SWR of 1:1. Note that the dipole described above is resonant (has equal and opposite values for any inductive and capacitive reactance), but the impedance of the antenna is about 70 ohms, not the 50 ohms that modern transceivers expect. The SWR measured for this antenna system would be about 1.4:1. Antennas that are resonant do not necessarily present a 50 ohm load to the radio, and therefore may not measure 1:1 on the SWR meter.

[2] This discussion was lifted from Jerry Sevick's book *The Short Vertical Antenna and Ground Radial*

An alternative is to use precise mathematical models of antenna performance available in sophisticated computer programs such as EZNEC+, software developed by Roy Lewallen, W7EL. Computer antenna modeling is a time-tested way of providing representative data and performance characteristics for antennas deployed in a wide range of environments. By using antenna modeling we can be explicit about the antenna design, environmental factors, and other assumptions that influence antenna performance.

Consider a model for our 80m center-fed horizontal dipole described above. A diagram from an EZNEC+ computer model for this antenna appears in Figure 5.

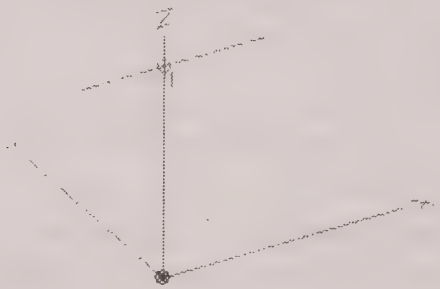


Figure 5 Dipole 80m center-fed (from EZNEC+ antenna model)

The wires for each wing of the dipole are 63 feet in length. The three dimensions North-South, East-West, and Up-Down are represented by the notation X, Y, and Z. The dipole is shown high on the Z axis with its arms extending along the X axis. Note the small circle in the center of the dipole. This circle represents a feedpoint and is annotated with a '1', indicating this is "feedpoint 1." It is possible for some antenna systems to have multiple feedpoints.

Antennas are defined within an EZNEC+ model by creating and positioning *wires*. These wires can be made of wire, aluminum tubing, or any other material likely to be used as an element of an antenna. The position of the wires is specified by identifying their end points in space (X_1, Y_1, Z_1)—(X_2, Y_2, Z_2). In this example there is a single wire fed in the middle at feedpoint 1.

Antennas are typically resonant at a single frequency, not for a whole band. At any frequency other than the resonant frequency there is an imbalance between the inductive and capacitive reactance, and that resulting reactive component will appear as part of the feedpoint

impedance. The resonant frequency for our example antenna is just over 3.8 MHz. Below this frequency the antenna is too short and has capacitive reactance (a negative reactance value). Above this frequency the antenna is too long and has inductive reactance (a positive reactance value). As the feedpoint impedance changes the SWR changes with it as illustrated in Figure 6.

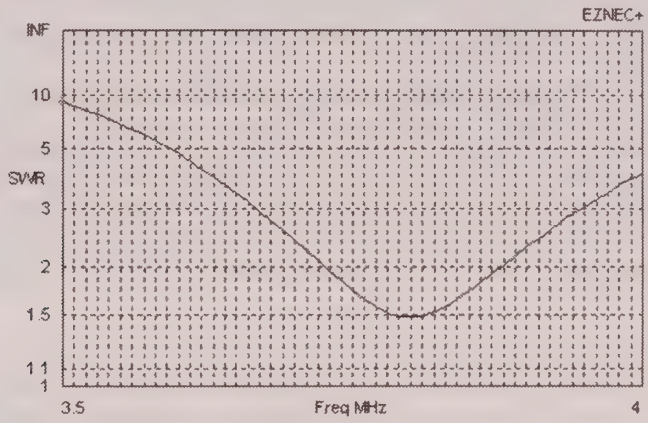


Figure 6 SWR curve and data for 80m center-fed dipole

At 3.8 MHz the SWR is 1.5:1 and the feedpoint impedance is 74 -j2 ohms. That is, the *real* resistance (non-reactive) is 74 ohms and the reactive component is -j2 ohms, where the reactive component value is marked by a lower case *j*, and the sign of the reactive component indicates whether it is inductive (positive) or capacitive (negative). Table 4 contains feedpoint impedance components and the resulting SWR.

MHz	Real	Reactive	SWR
3.5	59	-143	8.9
3.6	64	-96	4.7
3.7	65	-82	3.9
3.8	74	-2	1.5
3.9	80	+44	2.4
4.0	86	+91	4.0

Table 4 Whole band SWR values for the 80 meter dipole

It is easy to see why dipoles are such popular antennas. The 80m dipole covers much of the band with just a small amount of reactance away from the center resonant frequency. That reactance can be easily cancelled with an equal and opposite reactance supplied by an antenna tuner.

If we could always erect a full-sized antenna at any height we desired there would be no need for the *Buddipole*. Of course, many environments preclude erecting antennas such as this 80m dipole. Instead, we must compromise on the size of the antenna, its deployment height, or other

factors. How will such compromises affect antenna performance? The answer is twofold: [1] the radiation pattern from the antenna will differ from one in free space, and [2] antennas closer to the ground will have their efficiencies affected as the ground will cause higher losses. We will examine the radiation pattern first.

It is convenient to begin this discussion with the notion of an *isotropic radiator*, an imaginary antenna that occupies a single point in space. When it radiates the RF power emanates from this point in all directions uniformly. Imagine a single point at the exact center of a glass sphere shining its light outward to every point on that sphere. The sphere would be illuminated evenly across its entire surface. This idea, the radiation of energy uniformly in all directions, is the basis of most comparisons we shall make.

The baseline radiation measurement for any point on our glass sphere is 0 dBi. Remember that dBs represent ratios of power. The power 0 dBi is the power that an isotropic radiator would put on a spot on the surface of a surrounding sphere. Later, when we put an antenna of our own design inside this notional sphere, we can compare how much (or less) powerful our antenna is shining on a particular point with its energy compared to that of an isotropic radiator. Whenever you see dBi in antenna power descriptions you should have a mental model of that antenna inside a giant glass sphere (or partial sphere), and the dBi value will indicate how much power your antenna is delivering to a particular point compared with this standard power level of 0 dBi. Consider the plot in Figure 7.

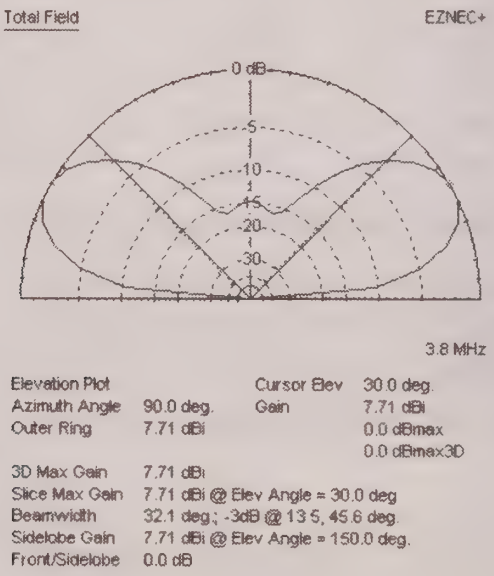


Figure 7 Far field plot for 80m dipole at 130 feet

The plot is from EZNEC+ and it shows the radiation pattern for the 80m dipole deployed ½ wavelength above the ground (at 130 feet). The plot shows a single slice through the hemisphere with our antenna in the middle along the bottom axis. There are several text items below the plot that we will examine in a moment. For now, look at the semicircle and its rings. The outer ring is marked 0 dB, inner rings are marked -5, -10, -15, -20, and -30. The 0 dB ring provides a reference to the maximum power output by the antenna. Just as lines on a road map mark off the miles, these rings mark off divisions within the plot. The -5 ring indicates a power 5 dB lower than that of the outer ring (the 0 dB ring). The -10 ring indicates a power 10 dB lower than that of the outer ring, and so on. This is an elevation plot so the line at the bottom of the semicircle represents the horizon, and the point at the top represents the zenith.

Imagine you could walk around the perimeter of this semicircle, and that the energy emitted from the antenna was visible light shining on the surface of that hemisphere we described above. The plot, which looks like two big lumps at 2 o'clock and 10 o'clock, indicates the relative strength of the radiation at that angle. So, if you start your walk at the 3 o'clock position along the very bottom of the plot the light is very dim. As you slowly walk along the perimeter of this semicircle you see the light beginning to get brighter. At some point, as you continue to walk slowly along the edge of the semicircle, the light changes its intensity quite quickly. By the time you reach the 2 o'clock position it is at full intensity. You continue to walk towards 12 o'clock and the light begins to dim again.

There is a 15 dB difference between the point in the plot where the most power is delivered (about 2 o'clock) and straight up 12 o'clock. How many S-units is that? Assuming 6 dB per S-unit, this represents a drop in power 2.5 S-units.

Read the text below the plot. Note the annotation for the outer ring indicates it is 7.71 dBi. That is, the outer ring (which is also the maximum of radiation in our plot) is 7.71 dBi, or 7.71 dB above the power an isotropic radiator would have delivered to that point. How is this possible? We cannot create energy, after all. How can we output more power just because we changed antennas from an isotropic radiator to this 80m dipole?

The answer to this is easy. We did not create energy; we moved it around. The isotropic radiator shined on every point of that imaginary sphere. This 80m dipole leaves much of the sphere dim or dark and concentrates its light on the portions of the sphere that corresponds to

directions we care about. That is, we aim the power where it will most likely be heard by other stations.

The plot in Figure 7 is an elevation plot showing the radiation pattern from horizon to zenith. The plot in Figure 8 is an azimuth plot looking down on the antenna system from high above. An azimuth plot also takes a slice of the sphere (just as the elevation plot was a slice). Azimuth plots for dipoles are usually taken from the same plane as the height of the antenna.

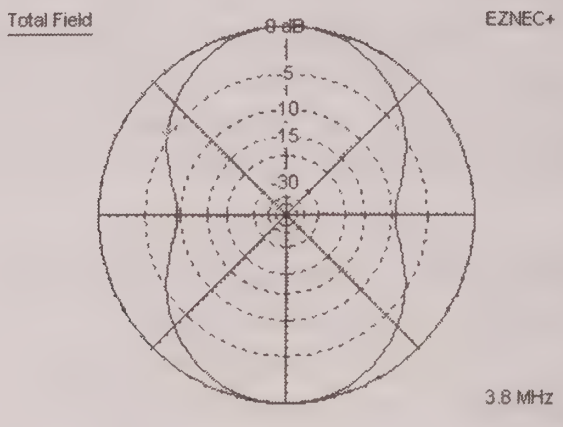


Figure 8 Azimuth plot for an 80m dipole at 130 feet

If we consider the top of the figure North (where the 0 dB marking is), then the dipole is oriented such that it runs East-West. The *gain* of the system is broadside to the dipole. Gain is the direction of most intensity for the emitted signal. One gain lobe runs North, and the other South. If there is gain then there are other directions where power is lower. In this case, power is 10 dB lower, relative to the direction of the highest output power, off the end of the dipole. Signals from or to this direction will be roughly 2 S-units lower than those broadside to the antenna.

It is possible to have an efficient antenna that effectively generates RF energy, but have that energy be focused in a useless direction. It is unimportant how bright your flashlight is if you never point it in the right direction! As it turns out, getting the pattern of the radiation for our antenna systems optimized appropriately is as big a challenge—or bigger—than getting the antenna system efficient. Plots such as the azimuth and elevation plots from EZNEC+ will be used to help make these analyses and optimizations.

Consider a different antenna. A *Buddipole* configured for 10m on an 8 foot *Buddipole* mast is shown in Figure 9. The antenna is shown to run along the Y axis. The orientation in space within the model is arbitrary

so long as the components are correctly sized, configured, and positioned.

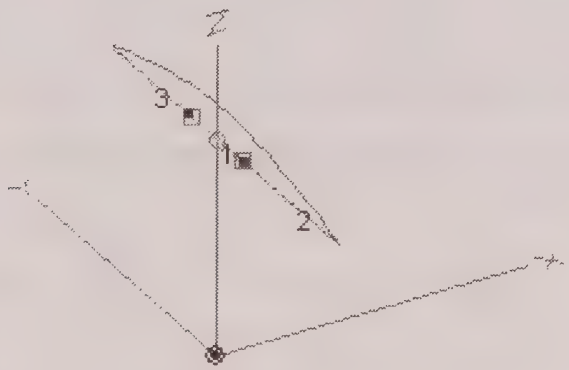


Figure 9 Model view of a *Buddipole* for 10m at 8 feet

The resulting SWR plot shows this antenna to be a nice match for a 50 ohm transceiver.

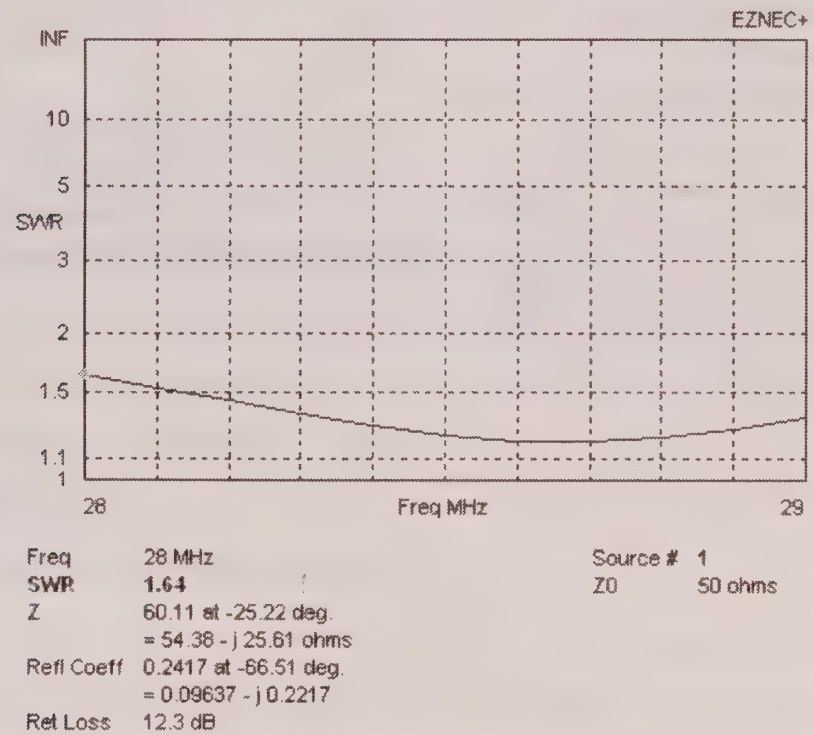


Figure 10 SWR plot for a *Buddipole* for 10m at 8 feet

The SWR is well below 2:1 for the frequency range 28.0 to 29.0 MHz. This would leave a feedpoint impedance of roughly 54 ohms. More

details, including the important comparison to the isotropic radiator, can be found in the elevation plot in Figure 11.

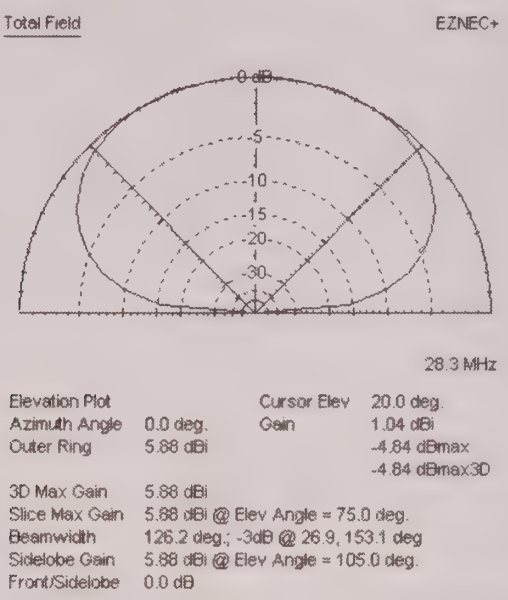


Figure 11 Elevation plot for a *Buddipole* on 10m at 8 feet

The outer ring on this plot is 5.88 dBi. But, this plot looks significantly different than the one for the 80m dipole at 130 feet. Most of the radiation is directed up towards the zenith. Power levels below 45 degrees from the horizon taper off quickly. At 20 degrees (approximately) the power is 5 dB below the peak. At 15 degrees power is 10 dB below the peak. At 10 degrees we are 15 to 20 dB below the peak.

Near Vertical Incident Skywave (NVIS) antennas do intentionally radiate towards the zenith. They are popular antennas for HF close-in communication. But, they use the 80m and 40m bands for this activity, not 20m or above, as the ionosphere does not reflect higher frequency signals well at high angles. The Buddipole makes an excellent NVIS antenna on those lower bands.

Consider the area of the plot 15 to 20 degrees either side of the zenith as illustrated in Figure 12. This area is highlighted as a shaded triangle.

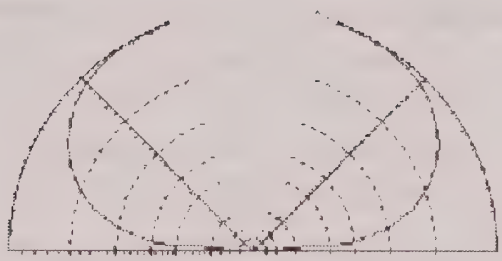


Figure 12 Radiation towards the zenith from a 10m antenna at 8 feet

Radiation from our antenna that travels straight up, or nearly straight up, is essentially lost as the ionosphere never (or nearly never) supports reflections at this frequency and at this angle. It does not matter how efficient your antenna is if the next stop for your signal is the moon or a distant star. In fact, the area blotted out in Figure 12 is probably too small to accurately depict the signal lost in this way. Much more is probably wasted than is shown here.

The remaining area of the plot is the useful radiation. How much is that? Making an estimate by inspection from the plot, the remaining area *not* wasted is perhaps 50% of the original. Again, if one were in this situation and given the choice of (a) making the antenna more efficient or, (b) making the pattern of the radiation different to reach more stations, the obvious choice of action would be (b) alter the antenna's pattern. Efficiency isn't the problem; direction is the problem.

The general rule is to have a dipole deployed at least ½ wavelength above the ground to reduce the effects of ground on its radiation pattern. In this case, a 10m antenna should have been deployed 5 meters about the ground, or roughly 16 feet. Taking that same antenna and moving it to 16 feet (on top of a 16 foot *Buddipole* mast) performs as the plot in Figure 13 illustrates.

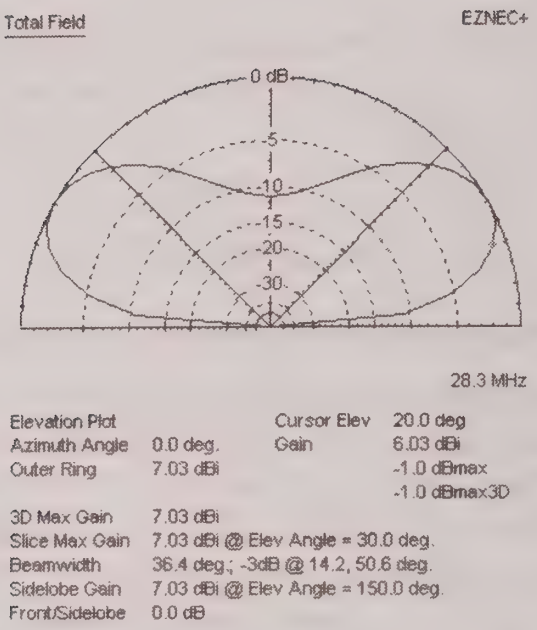


Figure 13 Elevation plot for a *Buddipole* for 10m at 16 feet

This plot looks very similar to the one for an 80m dipole at 130 feet. The configuration was exactly the same as the *Buddipole* dipole described above (for 10m at 8 feet)—only the deployment height above ground was changed. With the dipole at the proper height (about ½ wavelength above the ground) the radiation pattern gives us good gain at 20-30 degrees elevation (where our remote stations await our signals), and little energy is emitted from 45 degrees to the zenith.

Note that the outer ring now represents 7.03 dBi of gain over an isotropic radiator. The antenna at 8 feet had an outer ring value of only about 5.88. One dB is not very much, but at least it is a gain and not a loss! That gain was most likely because we got the antenna farther away from the lossy ground. More importantly, the gain at the radiation angles we care about (10-30 degrees for DX) is larger. At 20 degrees we go from 1 dBi at 8 feet to 6 dBi at 16 feet. **That is, we gained almost an S-unit in useful power by deploying the antenna properly.**

Energy lost to heat, or the reduction of current because of inductive or capacitive reactance, reduces the efficiency of our antenna system. These losses reduce antenna efficiency. Once we have deployed the antenna at the correct height, or otherwise constructed the antenna so that the radiation pattern is useful, we should attempt to maximize the current through the antenna by minimizing losses. The two largest losses are likely to be *ground losses* and *feedpoint reactance,* both of which limit current.

The remainder of this book will utilize these concepts to select *Buddipole* configurations and deployment strategies that will optimize the potential of the antenna. We shall examine not only antenna efficiency but also the radiation pattern for that antenna as deployed. Again, an efficient antenna sending its signal in the wrong direction is still useless!

Antenna modeling will continue to be used to justify decisions made throughout the text. A complete set of model files used for the figures in this book are available from the *Buddipole*, Inc. web site and other locations. Readers are encouraged to obtain a copy of EZNEC+ and explore these models to get a feel for how even small changes to an antenna design or deployment can make big differences in its performance.

Finally, the recommendations herein are just that: recommendations. There are so many factors that cannot be fully parameterized (the effects of ground, the effects of irregular terrain, specific situations with the proximity of buildings, etc.) that no book, no matter how ambitious, could fully describe an optimal solution for all situations. It is hoped, however, that the guidance within this book will be sufficient that the reader will be able to make good choices in their *Buddipole* antenna deployments.

5 Balconies and Rooftops

The *Buddipole*, like all antennas, operates best in the clear and at a proper height for its design. One of the best ways of getting the antenna into the clear is to deploy it off a balcony or rooftop. As discussed in chapter 4, a 10m dipole deployed at 8 feet generates a radiation pattern with much of the signal aimed upward. Even using the 16 foot mast does not help any band but 10m with this problem. The antenna must go higher to flatten out the radiation pattern. For that, a balcony or rooftop is just the place.

20m Buddipole on VP2M

The discussion below shows antenna configurations constructed from the parts in the standard *Buddipole* package. This includes the standard coils, a single 22 inch antenna arm for each element (or a pair of 11 inch arms), and the standard 5.5 foot whips. The standard tuning guide in Table 1 for coil and whip settings is a good starting point for configuring the *Buddipole.*

Additionally, configurations constructed from parts in the standard *Buddipole* package, along with the longer whips offered from the *Buddipole*, Inc. accessory catalog, are also shown. The extended whips are approximately 9.5 feet in length and are a substantial improvement over the original 5.5 foot whips. The longer whips provide the following benefits:

- **Make antennas without coils.** The 5.5 foot whips always require a coil to make antennas for the 10m band and below. The longer 9.5 foot whips allow you to make 10m and 12m antennas without any coils using just arms and whips alone.
- **Antennas are easier to tune.** Antennas with large coil components and short radiators can be finicky to tune. The longer the radiator the easier it is to tune the antenna to resonance. A standard *Buddipole* using the short 5.5 foot whips is moderately difficult to tune properly on 40m. Tuning is quite easy when the 9.5 foot whip is used.

- **Longer radiators make more efficient antennas.** Radiation resistance comes from the part of the antenna load that does work. This work is not done in the coils; this is done in the radiator. The more radiator length present in the antenna, the higher the radiation resistance will likely be. The closer the antenna design is to a full-sized antenna the better it will perform.
- **More radiator length usually means more 2:1 bandwidth.** The *bandwidth* of an antenna is defined to be the range of frequencies available with an SWR less than or equal to 2:1. The more radiator length the antenna has, the fewer coil turns that needs to be used for any given band. Using fewer coil turns usually leads to more 2:1 bandwidth.

Dipole antennas are designed to operate in the clear. For a dipole, this means it should be deployed ½ wavelength high to avoid undue influences by the ground. The standard *Buddipole* tuning chart does not assume a deployment ½ wavelength up; the tuning chart assumes the antenna will be deployed at 8 feet on the standard tripod and mast. By deploying the antenna off a balcony or rooftop we have violated this assumption.

If you take a dipole at ½ wavelength and lower it the resonance frequency will fall as it gets closer to the ground. Conversely, if you take a dipole like the *Buddipole*, which is configured for a particular resonance point at 8 feet, and raise it to 25 feet the resonance frequency will go up. The difference in frequency can sometimes be several hundred kilohertz.

As stated, the standard tuning guide in Table 1 for coil and whip settings is a good starting point for configuring the *Buddipole*. However, because we are deploying the antenna far above 8 feet there may be some adjustments that will need to be made for either whip lengths or coil taps. If you raise the antenna the resonance point will also rise, making the antenna look too short. To compensate, try extending the whip on each end by increments of a small amount (an inch or two) to bring the antenna back into resonance at the frequency you desire. If the whips are fully extended then an additional increment of coil tap on each side may be necessary.

The standard tuning guide in Table 1 for coil and whip settings is for a standard *Buddipole* at 8 feet. A new table for the 9.5 foot whips can be found in Table 5. The settings below assume a deployment at 25 feet.

BASIC DIPOLE TUNING WITH 9.5 FOOT WHIPS (ANTENNA @ 25 feet)						
Bands	RED SIDE COIL			BLACK SIDE COIL		
	Coils	Total whip sections out	Tap	Coils	Total whip sections out	Tap
40 METERS	Yes	6	25	Yes	6	24
30 METERS	Yes	6	13	Yes	6	13
20 METERS	Yes	6	7	Yes	6	8
17 METERS	Yes	6	3	Yes	6	3
15 METERS	No	9 feet	—	No	9 feet	—
12 METERS	No	6 No arms	—	No	6 No arms	—
10 METERS	No	5 No arms	—	No	5 No arms	—

Table 5 Tuning guide for standard *Buddipole* with 9.5 foot whips @ 25 feet

Key accessories for balcony and rooftop use are:
- 16 foot mast
- two 9.5 foot whips

The 16 foot mast and tripod cannot lift a ground mounted horizontal dipole high enough to present a reasonable radiation pattern for any band lower than 10m. However, the 16 foot mast is a fine accessory to have when deploying a *Buddipole* off a balcony or rooftop. This long mast (on top of a high building) can be the next best thing to having a tower!

The remainder of this chapter discusses the deployment of balcony and rooftop *Buddipole* systems using both the standard length (5.5 foot) and extended length (9.5 foot) whips. Each band is discussed in turn, and side-by-side comparisons of the SWR plots are shown for the two configurations (standard and extended length whips). These side-by-side comparisons show how using the longer whips can provide extra 2:1 bandwidth for a given band.

Note: The measurements and settings used below were taken from the author's deck which is approximately 10 feet from ground level. Your results and required settings may differ from those shown here.

Buddipole Balcony and Rooftop Cookbook

Buddipole configurations for use on balconies and rooftops are described in the next few pages. These configurations are organized by band and deployment height. For example, the 10m horizontal dipole is shown deployed at 16, 20, 25, and 30 feet above ground.

There are several options for most of these antenna configurations. The first option is the standard (or deluxe) *Buddipole* with a single arm on each side of the VersaTee, standard coils (if necessary), and standard 5.5 foot whip antennas. The great thing about the *Buddipole* is its ability to accept additional or alternate components to create new configurations. For example, one can substitute 9.5 foot whips for the standard 5.5 foot ones, or add additional arms, or use the *Low Band Coil* instead of the standard coils. Alternative configurations are also highlighted. The alternate construction techniques will not alter the far field pattern of the antenna, but it might make it more efficient (emitting more power). Creating an antenna without the need for coils is better than including coils, longer whips are better than shorter whips, and the larger coils have lower losses than the smaller coils. Size matters. Making a full-sized antenna is much better than creating shortened configurations.

WARNING

Never deploy the *Buddipole* or any antenna anywhere near power lines. High voltages exist in auras around power lines so a deadly jolt can be delivered even if you only bring the antenna close to the wires. Always survey the area around any prospective deployment. Stay safe. Stay well away from power lines.

Artwork with each configuration provides an at-a-glance view of how the antenna is constructed. For example:

shows (from left to right) a whip, coil, arm, VersaTee, arm, coil, and whip. If the coil and arm were not needed, the picture would look like this:

whip, VersaTee, and second whip. This diagramming technique will be used throughout the book to make component requirements for a particular configuration easy to assess.

There are benefits to deploying a full-sized antenna. They are more efficient than their shortened counterparts and they are easier to tune in the field. Configurations that are full-sized are marked with this symbol:

10m horizontal dipole

A 10m dipole is relatively compact measuring only 100 inches on each side. It can be constructed from the standard *Buddipole* components using just a small number of turns on the coils, or it can be made from only arms and whips using either additional accessory antenna arms, or the 9.5 foot whips. All configurations provide better than 2:1 SWR bandwidth across the entire 10m band.

Standard 5.5 foot whips

Red whip: 5 sections (56 inches)
Red coil: tap 2
Red side: one arm
Black whip: 6 sections (66 inches)
Black coil: tap 2
Black side: one arm

With 9.5 foot whips

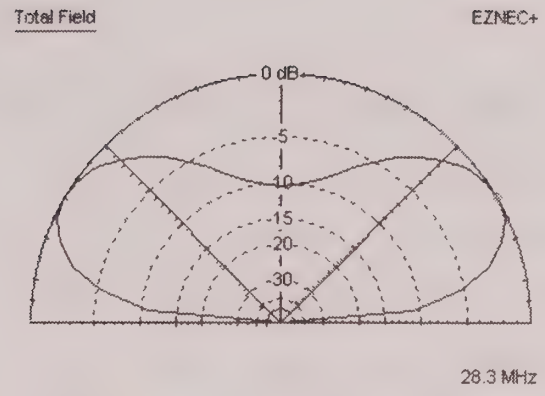
Red whip: 5 sections (100 inches)
Black whip: 5 sections (100 inches)

Standard 5.5 foot whips (2 arms)

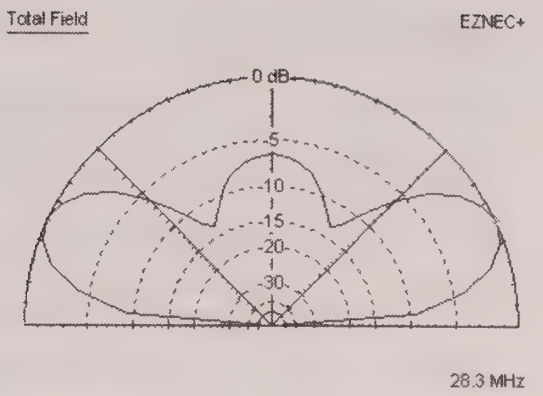
Red whip: 5 sections (56 inches)
Red side: two arms
Black whip: 5 sections (56 inches)
Black side: two arms

The best deployment height for a horizontal dipole is ½ wavelength above the ground. For a 10m dipole, ½ wavelength works out to be 5m, or approximately 16 feet. Moving the antenna higher distorts the far field pattern and a "bump" appears towards the zenith. Figure 14 contains far field plots for this antenna at 16, 20, 25, and 30 feet.

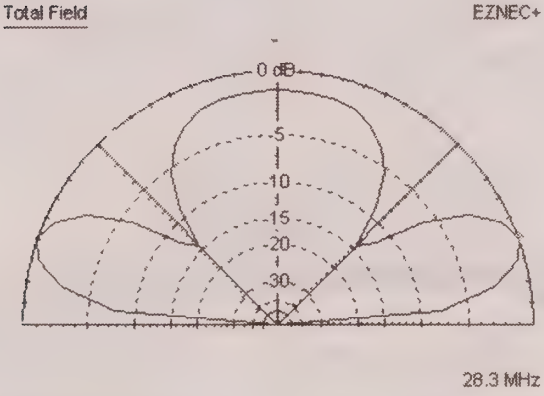
The low angle radiation lobes also drop from 30 degrees at 16 feet all the way down to 15 degrees at 30 feet. More worrisome is the deep null that begins to appear near the 45 degree angle as the antenna height increases. At 30 feet this null is nearly 20 dB between 30 and 40 degrees. For this reason 10m horizontal dipoles should not be deployed more than 20 feet above the ground.



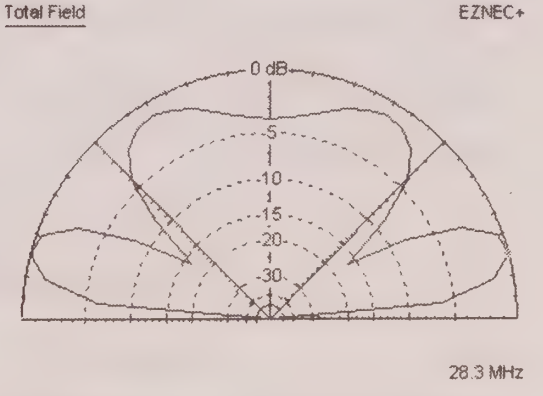
10m elevation plot at 16 feet



10m elevation plot at 20 feet



10m elevation plot at 25 feet



10m elevation plot at 30 feet

Figure 14 Far field pattern for a 10m horizontal dipole

12m horizontal dipole

A 12m dipole is 9.5 feet on each side (approximately 113 inches). It can be constructed from standard *Buddipole* components with only a few turns on each coil. The 12m dipole also corresponds to the size of the longer 9.5 foot *Buddipole* whips, which makes this antenna easy to configure with these accessories! Finally, the addition of an extra antenna accessory arm provides a way to eliminate the coil, thus making a near-full-sized antenna for this band with just two arms and the short (5.5 foot) whips. The total length of the antenna elements will be 44 inches from the arms + 66 inches from the whips, or 110 inches, a little short of the 113 inches indicated for this band, but the bandwidth of the antenna should bring the antenna close enough to work well. All antenna configurations provide better than 2:1 SWR bandwidth across the band.

Standard 5.5 foot whips

Red whip: 6 sections (all out)
Red coil: tap 2
Black whip: 6 sections (all out)
Black coil: tap 4

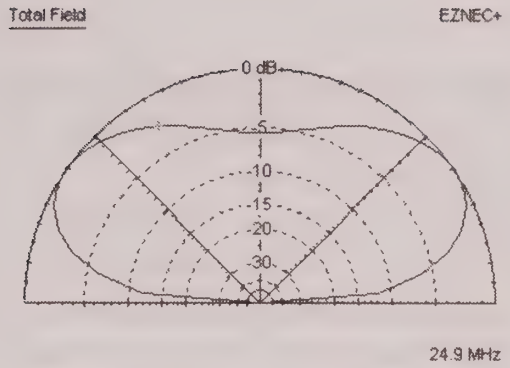
With 9.5 foot whips

Red whip: 6 sections (all out)
Black whip: 6 sections (all out)

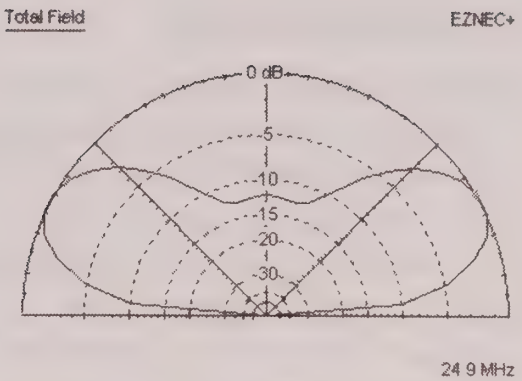
Standard 5.5 foot whips (2 arms)

Red whip (standard): 6 sections (all out, 5.5 feet)
Black whip: 6 sections (all out, 5.5 feet)

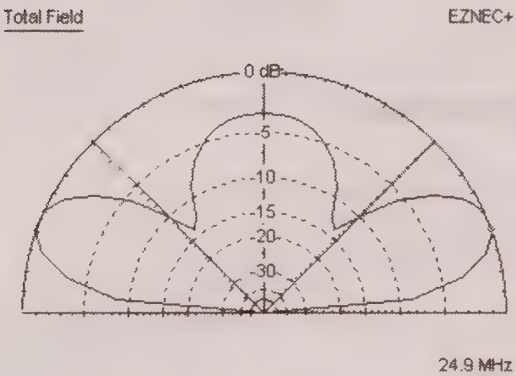
The best height for a 12m horizontal dipole is ½ wavelength above ground—6m (19.7 feet). Deploying the antenna above 20 feet induces a deep null at about 45 degrees in the far field. For this reason a 12m horizontal dipole should not be deployed more than 20 feet above the ground.



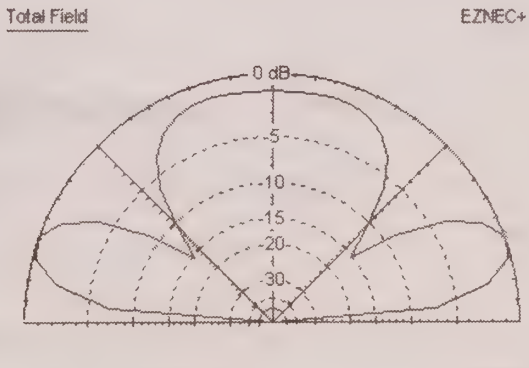
12m elevation plot at 16 feet



12m elevation plot at 20 feet



12m elevation plot at 25 feet



12m elevation plot at 30 feet

Figure 15 Far field pattern for a 12m horizontal dipole

15m horizontal dipole

A 15m dipole is 11 feet on each side (approximately 133 inches). It can be constructed from standard *Buddipole* components with only a few turns on each coil. The 15m dipole can also be made from the combination of a single antenna accessory arm and a 9.5 foot *Buddipole* whip extended to 9 feet. An additional arm, along with the standard *Buddipole* configuration, makes a nearly full-sized antenna. All antenna configurations provide better than 2:1 SWR bandwidth across the band.

Standard 5.5 foot whips

Red whip: 6 sections (all out)
Red coil: tap 4 (red)
Black whip: 6 sections (all out)
Black coil: tap 6 (black)

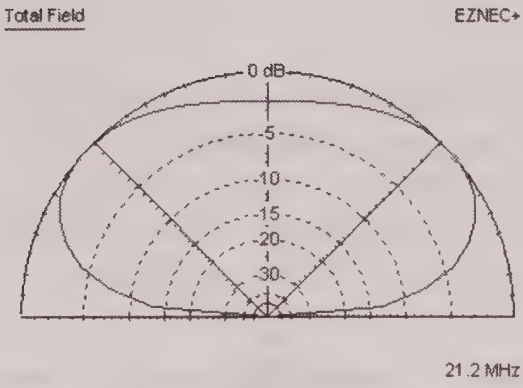
With 9.5 foot whips

Red whip: 9 feet (all but 6 inches)
Black whip: 9 feet (all but 6 inches)

Standard 5.5 foot whips (2 arms) with coils

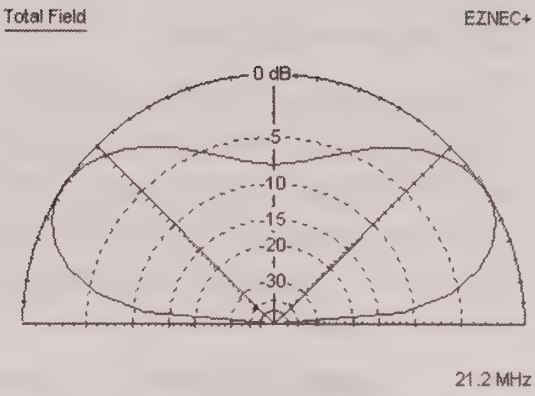
Red whip: 6 sections (all out)
Red coil: tap 2
Black whip: 6 sections (all out)
Black coil: tap 4

The best height for a 15m horizontal dipole is approximately ½ wavelength above ground—7.5m (24.6 feet). Figure 16 contains far field plots at various heights for a 15m dipole. Deploying the antenna above 25 feet induces a deep null at about 45 degrees in the far field. For this reason a 15m horizontal dipole should not be deployed more than 25 feet above the ground.



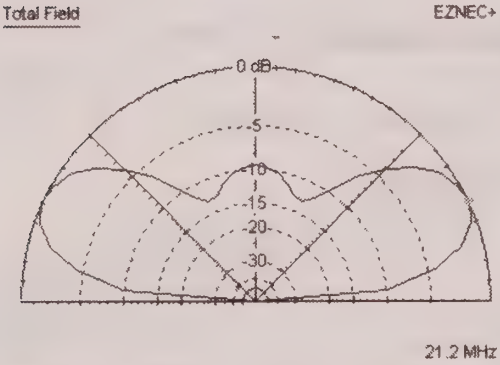
Elevation Plot		Cursor Elev	40.0 deg.
Azimuth Angle	0.0 deg.	Gain	5.89 dBi
Outer Ring	5.89 dBi		0.0 dBmax
			0.0 dBmax3D
3D Max Gain	5.89 dBi		
Slice Max Gain	5.89 dBi @ Elev Angle = 40.0 deg.		
Beamwidth	142.6 deg.; -3dB @ 18.7, 161.3 deg.		
Sidelobe Gain	5.89 dBi @ Elev Angle = 140.0 deg.		
Front/Sidelobe	0.0 dB		

15m elevation plot at 16 feet



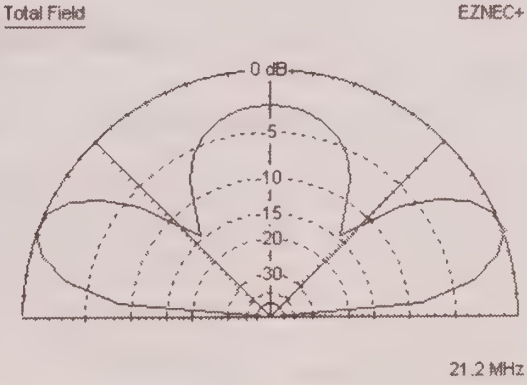
Elevation Plot		Cursor Elev	35.0 deg.
Azimuth Angle	0.0 deg.	Gain	6.53 dBi
Outer Ring	6.53 dBi		0.0 dBmax
			0.0 dBmax3D
3D Max Gain	6.53 dBi		
Slice Max Gain	6.53 dBi @ Elev Angle = 35.0 deg.		
Beamwidth	42.2 deg.; -3dB @ 15.0, 57.2 deg.		
Sidelobe Gain	6.53 dBi @ Elev Angle = 145.0 deg.		
Front/Sidelobe	0.0 dB		

15m elevation plot at 20 feet



Elevation Plot		Cursor Elev	25.0 deg.
Azimuth Angle	0.0 deg.	Gain	7.57 dBi
Outer Ring	7.57 dBi		0.0 dBmax
			0.0 dBmax3D
3D Max Gain	7.57 dBi		
Slice Max Gain	7.57 dBi @ Elev Angle = 25.0 deg.		
Beamwidth	29.5 deg.; -3dB @ 12.7, 42.2 deg.		
Sidelobe Gain	7.57 dBi @ Elev Angle = 155.0 deg.		
Front/Sidelobe	0.0 dB		

15m elevation plot at 25 feet



Elevation Plot		Cursor Elev	20.0 deg.
Azimuth Angle	0.0 deg.	Gain	7.66 dBi
Outer Ring	7.66 dBi		0.0 dBmax
			0.0 dBmax3D
3D Max Gain	7.66 dBi		
Slice Max Gain	7.66 dBi @ Elev Angle = 20.0 deg.		
Beamwidth	23.9 deg.; -3dB @ 10.4, 34.3 deg.		
Sidelobe Gain	7.66 dBi @ Elev Angle = 160.0 deg.		
Front/Sidelobe	0.0 dB		

15m elevation plot at 30 feet

Figure 16 Far field pattern for a 15m horizontal dipole

17m horizontal dipole

A 17m dipole is 12.9 feet on each side (approximately 155 inches). It can be constructed from standard *Buddipole* parts using coils for loading, or the 17m dipole can be made from the combination of two antenna accessory arms and a 9.5 foot *Buddipole* whip extended to 9 feet 3 inches. All antenna configurations provide better than 2:1 SWR bandwidth across the band.

Standard 5.5 foot whips

Red whip: 5 sections
Red coil: tap 10 (green)
Black whip: 5.3 sections
Black coil: tap 6 (black)

With 9.5 foot whips

Red whip: 6 sections (all out)
Red coil: tap 3
Black whip: 6 sections (all out)
Black coil: tap 3

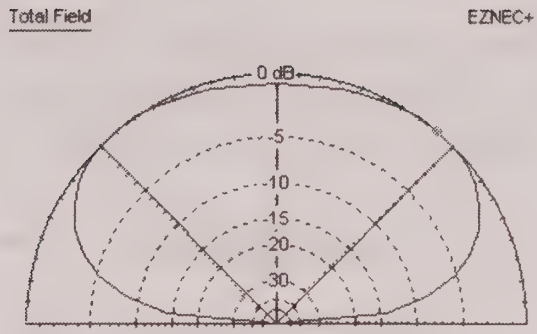
Standard 5.5 foot whips (2 arms) with coils

Red whip: 6 sections (all out)
Red coil: tap 8
Red side: two arms
Black whip: 6 sections (all out)
Black coil: tap 4
Black side: two arms

With 9.5 foot whips (2 arms)

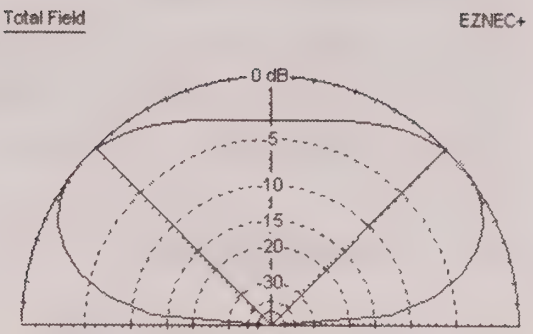
Red whip: 9 feet 3 inches
Black whip: 9 feet 3 inches

The best height for a 17m horizontal dipole is ½ wavelength above ground—8.5m (28 feet). Figure 17 contains far field plots at various heights for a 17m dipole.



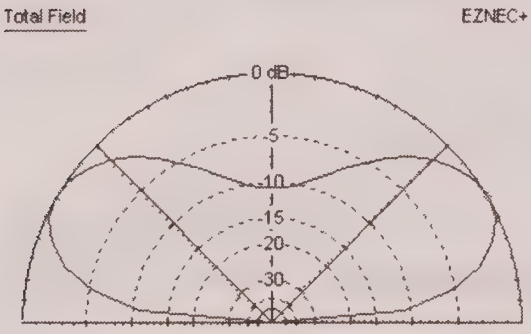
Elevation Plot		Cursor Elev	50.0 deg.
Azimuth Angle	0.0 deg.	Gain	5.67 dBi
Outer Ring	5.67 dBi		0.0 dBmax
			0.0 dBmax3D
3D Max Gain	5.67 dBi		
Slice Max Gain	5.67 dBi @ Elev Angle = 50.0 deg.		
Beamwidth	137.0 deg.; -3dB @ 21.5, 158.5 deg.		
Sidelobe Gain	5.67 dBi @ Elev Angle = 130.0 deg.		
Front/Sidelobe	0.0 dB		

17m elevation plot at 16 feet



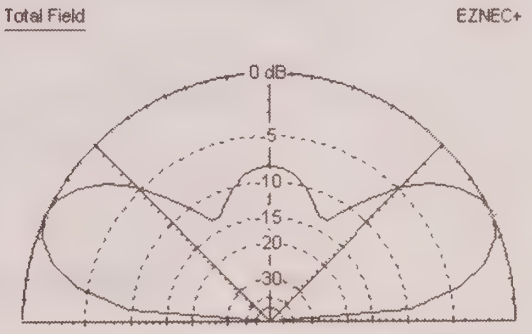
Elevation Plot		Cursor Elev	40.0 deg.
Azimuth Angle	0.0 deg.	Gain	5.97 dBi
Outer Ring	5.97 dBi		0.0 dBmax
			0.0 dBmax3D
3D Max Gain	5.97 dBi		
Slice Max Gain	5.97 dBi @ Elev Angle = 40.0 deg.		
Beamwidth	60.2 deg.; -3dB @ 17.7, 77.9 deg.		
Sidelobe Gain	5.97 dBi @ Elev Angle = 140.0 deg.		
Front/Sidelobe	0.0 dB		

17m elevation plot at 20 feet



Elevation Plot		Cursor Elev	30.0 deg.
Azimuth Angle	0.0 deg.	Gain	6.79 dBi
Outer Ring	6.79 dBi		0.0 dBmax
			0.0 dBmax3D
3D Max Gain	6.79 dBi		
Slice Max Gain	6.79 dBi @ Elev Angle = 30.0 deg.		
Beamwidth	37.3 deg.; -3dB @ 14.4, 51.7 deg.		
Sidelobe Gain	6.79 dBi @ Elev Angle = 150.0 deg.		
Front/Sidelobe	0.0 dB		

17m elevation plot at 25 feet



Elevation Plot		Cursor Elev	25.0 deg.
Azimuth Angle	0.0 deg.	Gain	7.58 dBi
Outer Ring	7.58 dBi		0.0 dBmax
			0.0 dBmax3D
3D Max Gain	7.58 dBi		
Slice Max Gain	7.58 dBi @ Elev Angle = 25.0 deg.		
Beamwidth	28.6 deg.; -3dB @ 12.4, 41.0 deg.		
Sidelobe Gain	7.58 dBi @ Elev Angle = 155.0 deg.		
Front/Sidelobe	0.0 dB		

17m elevation plot at 30 feet

Figure 17 Far field pattern for a 17m horizontal dipole

20m horizontal dipole

A 20m dipole is 16.6 feet on each side (approximately 199 inches). It can be constructed from standard *Buddipole* parts using coils for loading. All antenna configurations provide better than 2:1 SWR bandwidth across the band.

Standard 5.5 foot whips

Red whip: 4.5 sections (56 inches)
Red coil: tap 10 (green)
Black whip: 6 sections (all out)
Black coil: tap 15 (blue)

With 9.5 foot whips

Red whip: 6 sections (all out)
Red coil: tap 7
Black whip: 6 sections (all out)
Black coil: tap 8

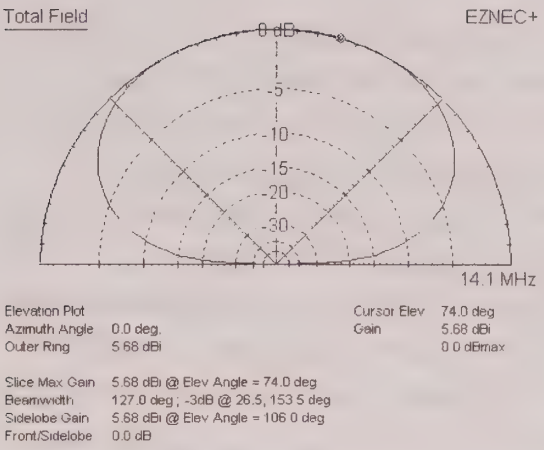
Standard 5.5 foot whips (2 arms) with coils

Red whip: 6 sections (all out)
Red coil: tap 8
Black whip: 6 sections (all out)
Black coil: tap 4

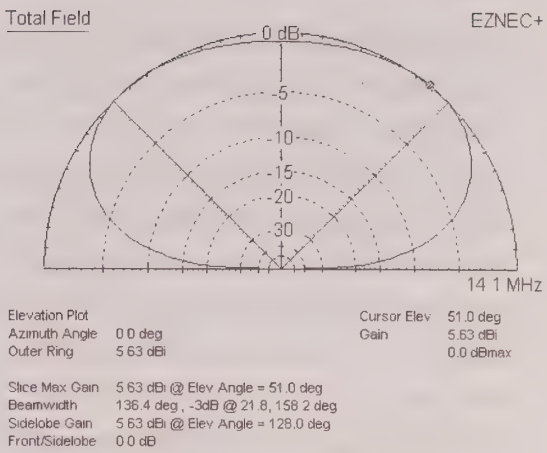
9.5 foot whips (2 arms) with coils

Red whip: 6 sections (all out)
Red coil: tap 6
Black whip: 6 sections (all out)
Black coil: tap 5

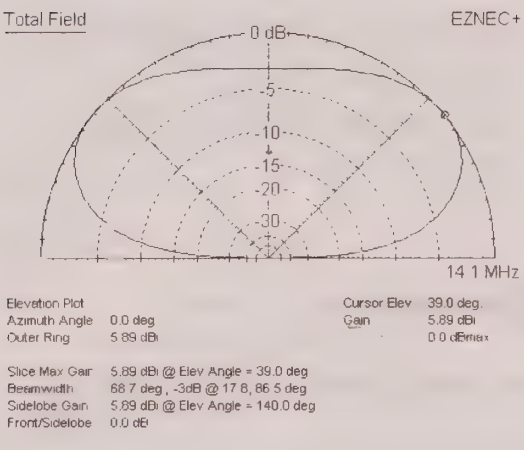
The best height for a 20m horizontal dipole is ½ wavelength above ground—10m (33 feet). Figure 18 contains far field plots at various heights for a 20m dipole. The far field pattern for this antenna is best when deployed at 30-35 feet.



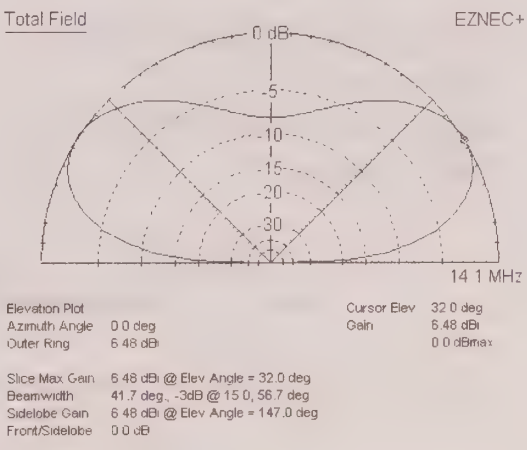
20m elevation plot at 16 feet



20m elevation plot at 20 feet



20m elevation plot at 25 feet



20m elevation plot at 30 feet

Figure 18 Far field pattern for a 20m horizontal dipole

30m horizontal dipole

A dipole for 30m should have element lengths of roughly 23 feet. The *Buddipole* configurations described below have element lengths ranging from just over 7 feet to about 13 feet. These shortened radiator lengths have a much lower expected radiation resistance, and present a significantly lower feedpoint impedance than a full-sized dipole. Tuning the smallest of the configurations will be difficult. It is highly recommended that longer whips, additional accessory antenna arms, or both be used for bands lower than 20m. All settings for whip lengths and coil taps are approximations. A *Triple Ratio Switch Balun* with a setting of 4:1 is required for all configurations.

Standard 5.5 foot whips

Red whip: 6 sections (all out)
Red coil: tap 21
Black whip: 6 sections (all out)
Black coil: tap 21

With 9.5 foot whips

Red whip: 6 sections (all out)
Red coil: tap 13
Black whip: 6 sections (all out)
Black coil: tap 13

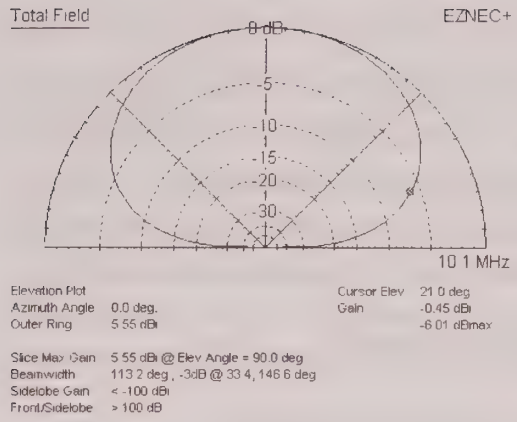
Standard 5.5 foot whips (2 arms) with coils

Red whip: 6 sections (all out)
Red coil: tap 21
Black whip: 6 sections (all out)
Black coil: tap 21

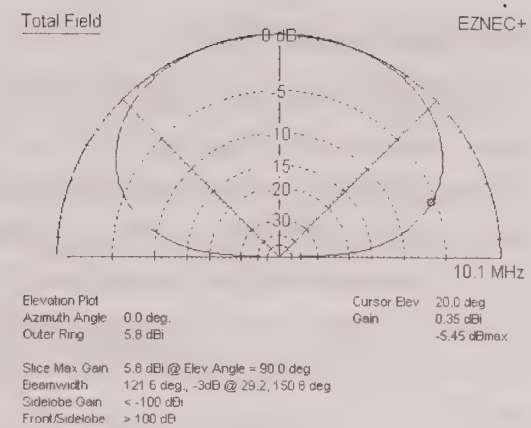
9.5 foot whips (2 arms) with coils

Red whip: 5+ sections (110 inches)
Red coil: tap 13
Black whip: 5+ sections (112 inches)
Black coil: tap 13

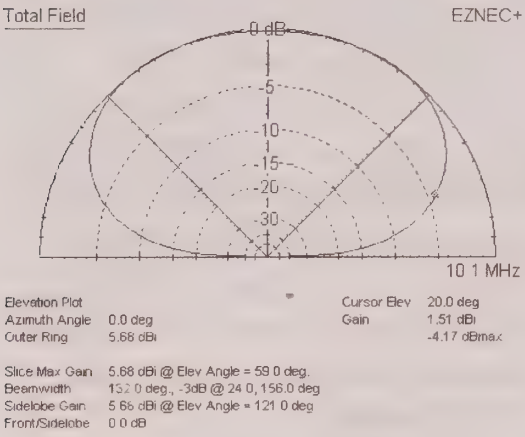
The far field plots for this antenna are shown in Figure 19.



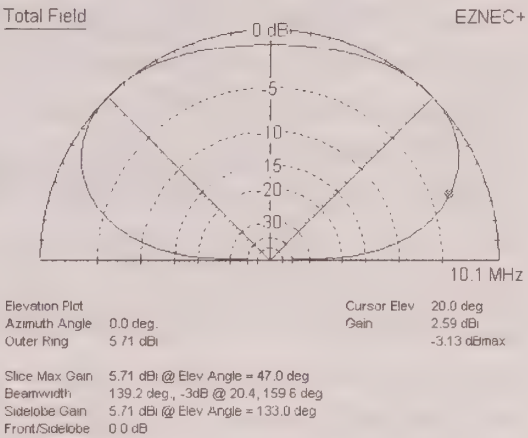
30m elevation plot at 16 feet



30m elevation plot at 20 feet



30m elevation plot at 25 feet



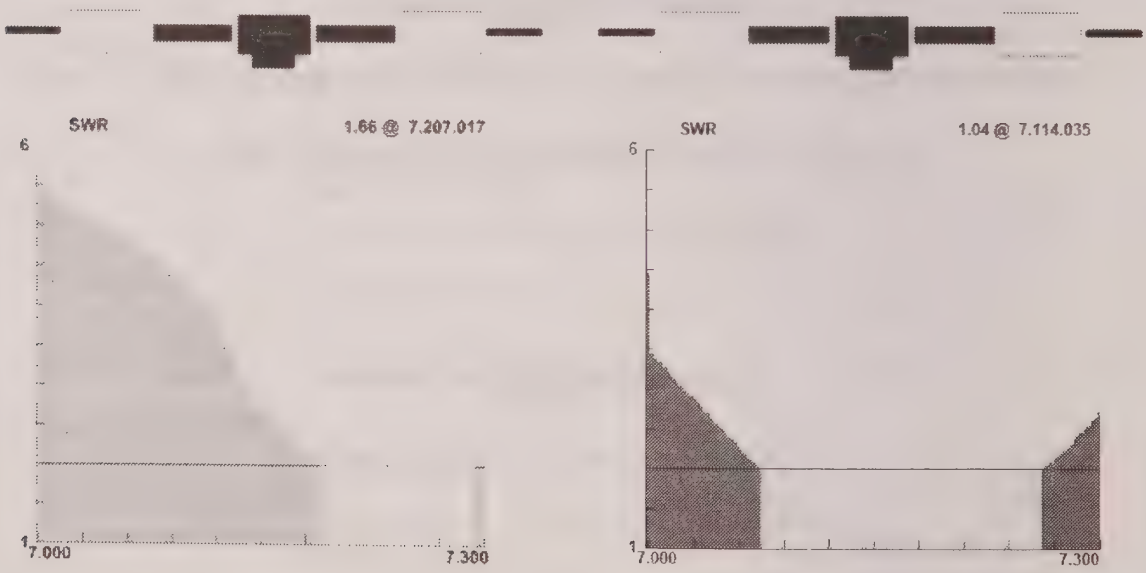
30m elevation plot at 30 feet

Figure 19 Far field pattern for a 30m horizontal dipole

40m horizontal dipole

A 40m dipole with a radiator arm length of only 7 to 14 feet is a very short antenna for this band. A full-sized element for this band is about 34 feet. Shortened antennas have a large capacitive reactance as a component of their feedpoint impedance. The standard *Buddipole* coils are just large enough (have enough inductive reactance) to cancel that capacitive reactance. Even so, the radiation resistance for this antenna will be very low. A TRSB with the setting 4:1 is required to make a good match.

The difference in length between the short (5.5 foot) and long (9.5 foot) whip is most noticeable on this band, the lowest band supported by the standard *Buddipole.* Adding that extra radiator length and reducing the number of coil turns necessary to achieve the match makes a big difference in the 2:1 SWR bandwidth for the antenna. The figure below with the antenna schematic, coil, and whip settings also includes a plot of the SWR directly measured from an antenna with these configurations. You can see that the short whip has a very small 2:1 SWR bandwidth (about 75-100 kHz) and the longer whip has a much larger 2:1 SWR bandwidth (about 150-200 kHz). The antenna with the longer whip will also be easier to tune in the field. As discussed in other places in this book, when it comes to radiators every inch counts!



Standard 5.5 foot whips

Red whip: 6 sections (all out)
Red coil: tap *none*
Black whip: 6 sections (all out)
Black coil: tap *none*

With 9.5 foot whips

Red whip: 6 sections (all out)
Red coil: tap *25*
Black whip: 6 sections (all out)
Black coil: tap *24*

Other configurations for this antenna are possible. The addition of extra arms helps a little, but those additional arms combined with the longer 9.5 foot whips help more.

Buddipole, Inc. sells a 12 foot shock-cord whip. Replacing the shorter whips with two of these 12 foot whips helps even more[3]. Alternatively, one could add a third antenna accessory arm with the 9.5 foot whips.

Standard 5.5 foot whips (2 arms) with coils

Red whip: 6 sections (all out)
Red coil: tap *none*
Black whip: 6 sections (all out)
Black coil: tap *none*

9.5 foot whips (2 arms) with coils

Red whip: 6 sections (all out)
Red coil: tap 25
Black whip: 6 sections (all out)
Black coil: tap 24

12 foot whips (2 arms) with coils
or 9.5 foot whips (3 arms) with coils

Red whip: 12 foot (all out)
Red coil: tap 20
Black whip: 12 foot (all out)
Black coil: tap 20

Note that all configurations will be affected by the height above ground and proximity to other objects. Even with the longest whips and extra arms this is a very short dipole for the 40m band.

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[3] *Buddipole*, Inc. does not recommend using 12 foot shock cord whips for horizontal element duty as they are very heavy and tend to sag. The additional arm used in conjunction with the 9.5 foot whip is preferred.

6 Ground Mounted Verticals

As discussed earlier, ground mounted horizontal dipoles on *Buddipole* masts and tripods cannot be raised to a sufficient height to achieve a reasonable radiation pattern for most HF bands. Only 10m dipoles when raised to a ½ wavelength in height (5 meters or about 16 feet) deliver the power to low angles that give us good DX opportunities. So, if horizontal dipoles are out, what simple deployment designs remain? Two options come to mind immediately: vertical dipoles and vertical monopoles with elevated radials. We'll examine each in turn.

Ground mounted vertical antenna for 17m on VP2M

Vertical dipoles are just as they sound: a dipole antenna deployed such that the elements are perpendicular to the ground instead of parallel to it. The two general problems deploying such antennas are managing its height (a full-sized 20m vertical dipole will be ½ wavelength high or 33 feet!), and to get the feed line to the feedpoint.

A dipole is typically constructed such that both elements lie straight on an imaginary line. In the case of a vertical dipole, both elements would be perpendicular to the ground, one element directly above the other. What about an antenna where the bottom element is not quite perpendicular? What about one where the bottom element is at a 45 degree angle to the ground? The collection of far field plots in Figure 20 show how the radiation pattern of a 10m antenna with its feedpoint at 15 feet changes as the lower element is rotated from directly under the top element (at 180 degrees from that top element) to perpendicular to it (at 90 degrees from that top element).

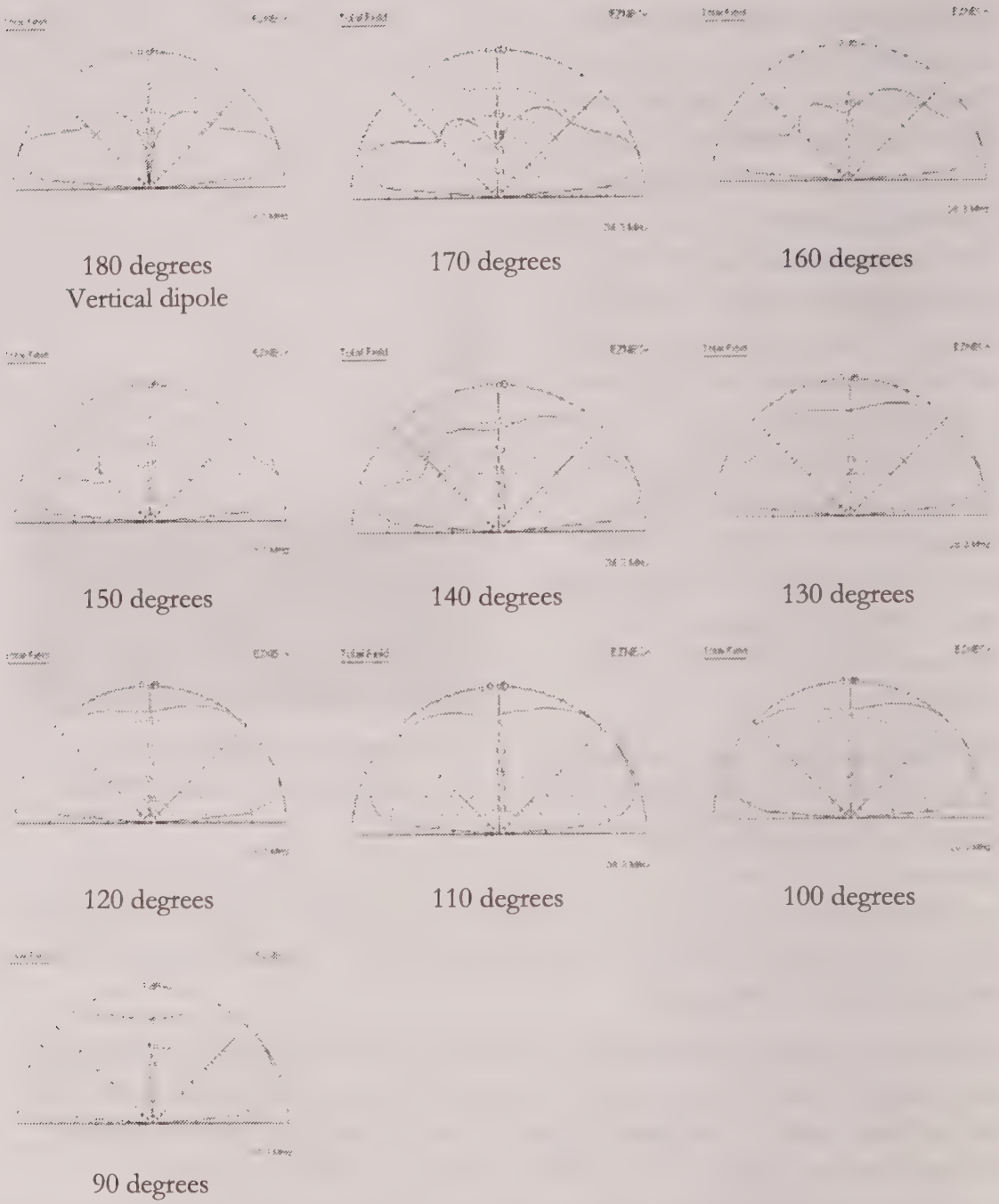
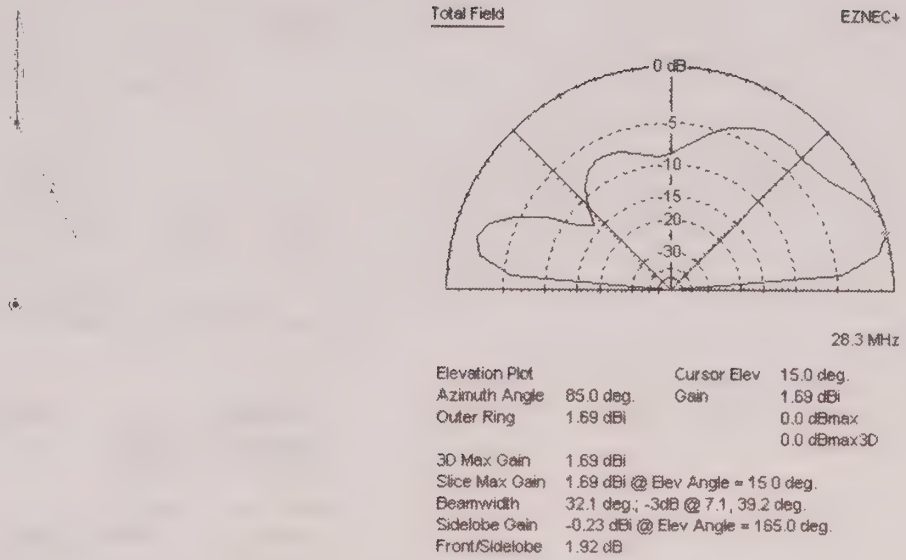


Figure 20 Far field pattern of a 10m antenna rotating the bottom element

Consider the antenna configuration when the lower element is extended at 150 degrees below the vertical. That is, there is a 150 degree angle between the elements. Dropping the single whip or wire at this angle makes setup easy, but is the antenna effective?

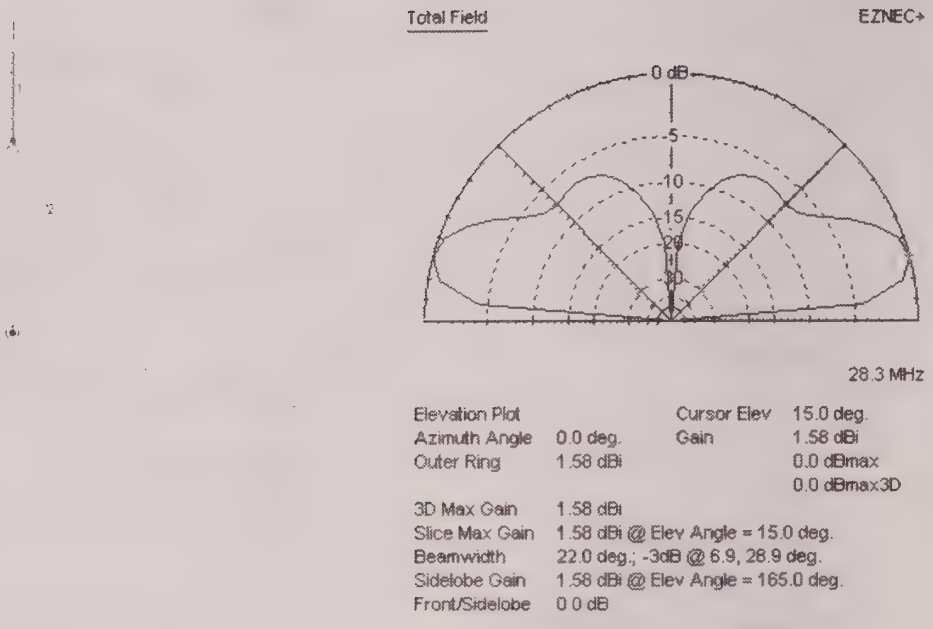


Antenna deployment **Far field elevation plot**

Figure 21 10m antenna with second element drooping at 150 degrees

Examine Figure 21 and note the large null at the 45 degree angle on the left side of the far field plot. In fact, the whole side away from the drooping lower element is down from 8 dB to 15 dB from the power predicted for the right side of the antenna (with the drooping element).

Adding a second sloping element on the opposite side of the first yields results as illustrated in Figure 22. The addition of the second lower element changes the pattern significantly, eliminating the deafness on the left side of the antenna. The maximum gain for the antenna was nearly unchanged. The second element simply eliminated losses. In other words, assuming this extra element was just a wire, running that wire cost us next to nothing in the relative gain of the antenna, but it eliminated losses and restored full sensitivity on all sides. But, is it still a vertical dipole in this configuration? It looks more like a vertical with a bad radial system (at least to the author).



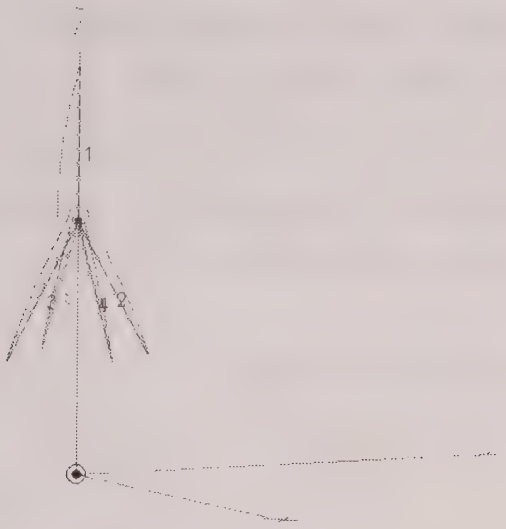
Antenna deployment **Far field elevation plot**

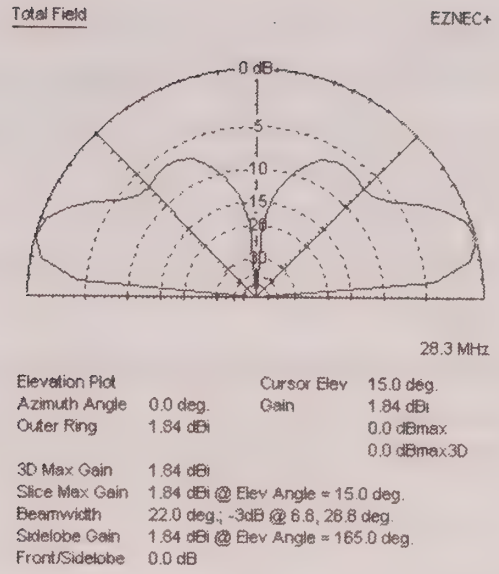
Figure 22 Antenna with two elements drooping at 150 degrees

A common way to create *Buddipole* vertical antennas is to use wire (instead of arms or whips) for the lower elements. The *Buddipole wire assembly* is a bundle of wire approximately 30 or 60 feet in length that terminates in a ¼ inch ring connector. A *Counterpoise Wire Adapter* reduces the standard $^3/_8$"x24 tap of the VersaTee to ¼". You can make your own version of this easily using kite winders and lengths of insulated wire. The *Counterpoise Wire Adapter* can be purchased separately.

Buddipole wire assembly

Creating four elements sloping down at this angle gives us a version of this antenna described in Figure 23.





Antenna deployment **Far field elevation plot**

Figure 23 Antenna with four elements drooping at 150 degrees

The far field pattern is similar to that with the two radials but the gain is slightly higher.

Radials	Max gain
1	1.7 dBi
2	1.6 dBi
4	1.8 dBi

Table 6 Maximum gain comparisons for 1, 2, and 4 radials at 150 degrees

All these gain numbers are ridiculously close and well within any measurement or modeling error. It takes a 3 dB change in power to register as half an S-unit. All these changes in forward gain are small fractions of a dB. The big change resulting from the addition of the second sloping element was the elimination of ground losses.

When there is only one lower element, and when that lower element is directly below the top element (in a vertical dipole), that lower element is one element in

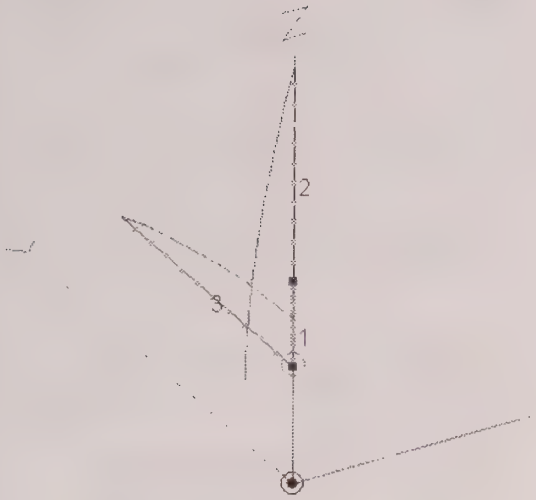
How many radials are needed? Is one wire enough? The answer often given is, "it depends." Well, perhaps. But adding additional radials reduces ground losses and often lowers the average angle of radiation—both very good things. The author recommends no fewer than 2 radials, and 4 or more radials are preferred. Deploying more than one ensures that you have no dead spots in your radiation (and receiving) far field pattern. It would be a shame to miss a rare DX contact for lack of running a single wire!

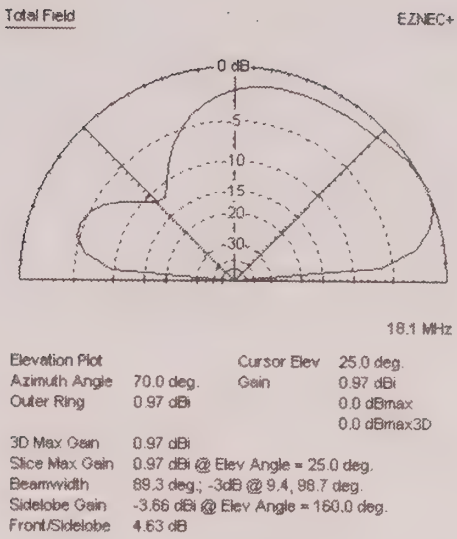
the dipole. However, as soon as we alter the relative positions of the lower element from 180 degrees to some smaller angle, the lower element begins to look more like a radial wire for a vertical than a second dipole element. Therefore, the non-vertical element of a vertical antenna will always be called a *radial.* All radials discussed in this book are *elevated radials* placed well above the ground, never on the ground, and never buried.

Adding additional radials usually lowers the angle of maximum gain from one near 30 degrees to an angle closer to 20 degrees. If you are working DX, this effect of lowering the angles of the main lobe is very helpful.

A more traditional ground mounted vertical antenna with elevated radials is easy to construct with the *Buddipole* and it performs very well when sufficient radials are provided. Consider a 17m antenna with the vertical component constructed from two arms (22 inches each) and a 9.5 foot whip. The approximate length for a ¼ wave vertical would be 12.9 feet (155 inches). The two arms account for 44 inches, leaving the whip to supply the remaining 111 inches (9 feet 3 inches), just shy of the whip's full length when extended.

A 17m vertical deployed at 5 feet with a radial extended away from the feedpoint also at 5 feet (90 degrees to the vertical) is illustrated below in Figure 24. Like the 10m antenna modeled earlier, the single radial on the 17m vertical creates an area of relative deafness in the pattern. Running even one additional elevated radial in the opposite direction of the first smoothes the pattern considerably as shown in Figure 25. The symmetry of the antenna is restored. If you wish to work more stations then the trade-off of having an imperceptible increase in power in one direction is more than offset by having good power in <u>all</u> directions. Again, the difference in deployment is only one wire (from one radial to two).



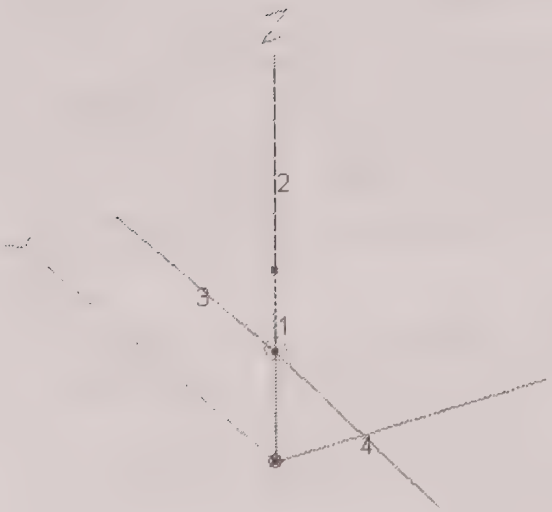


17m vertical with 1 radial **Far field plot for 17m w/ 1 radial**

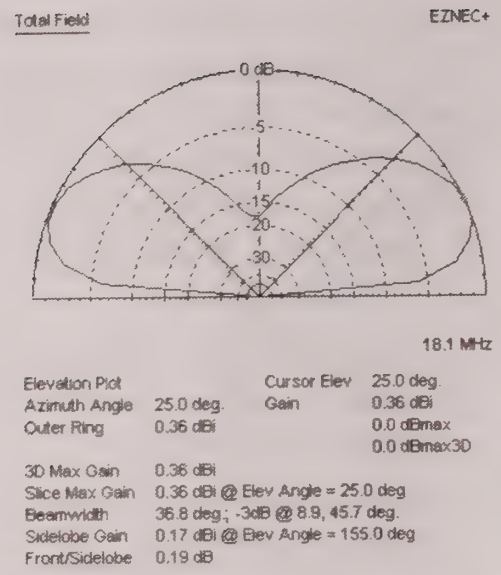
Figure 24 17m vertical with 1 elevated radial

In absolute terms, the gain number shown (0.36 dBi, in this example) is disappointing when compared to the performance of a horizontal dipole up ½ wavelength. Additional radials, as shown in Figure 26, do not increase the gain; it falls by a very small amount. But, the center of the main lobe of radiation falls from 25 degrees with two radials to just 20 degrees with four radials. The lower angle of radiation helps when chasing DX contacts, more than compensating for the imperceptible loss in power that the model predicts.

Will more radials help? Figure 27 shows that 17m vertical antenna configured with 16 radials. There are few differences between its performance and that of the one configured with just four radials.



17m vertical with 2 radials

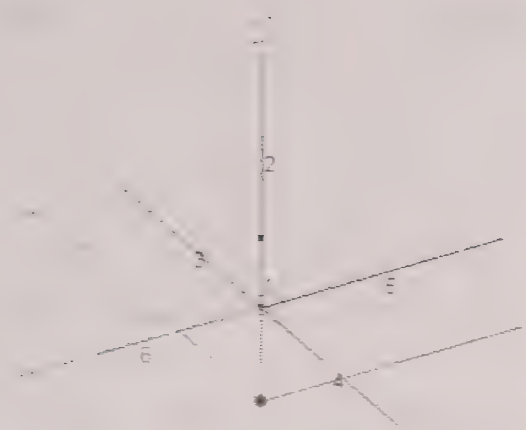


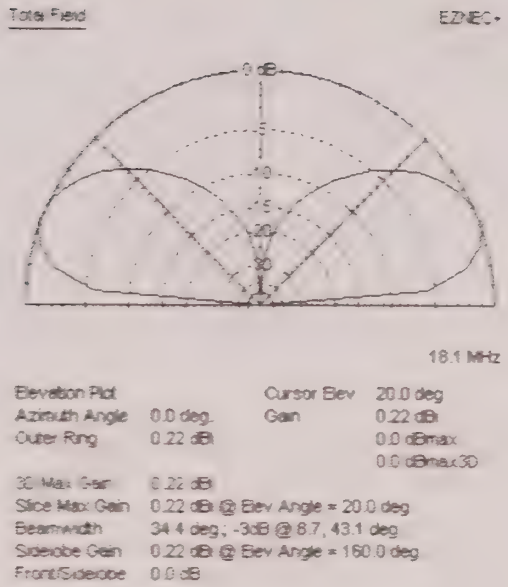
Far field plot for 17m with 2 radials

Figure 25 17m vertical antenna with 2 elevated radials

If we are only seeing 0.36 dBi of maximum gain, where is the rest of the energy going? Figure 28 shows this 17m antenna with four radials deployed over "perfect" ground. When we eliminate ground losses from the system we get all our power back. The modeling shows the antenna over "perfect" ground has nearly 6 dBi of gain! Can we get anything close to that in our deployments? Yes. Saltwater is an excellent conductor and deploying over saltwater (such as on the beach) significantly reduces ground losses, losing only 1 dB from the gain over "perfect" ground. A whole chapter of this book is dedicated to beach deployments.

Finally, notice the radiation pattern in the saltwater plot in Figure 28. The angle of maximum radiation is at 10 degrees! Depending on where in the world you are operating, this might actually be too low, but that is an easier problem to fix than an antenna that is inefficient, deaf in some directions, and radiating too high!

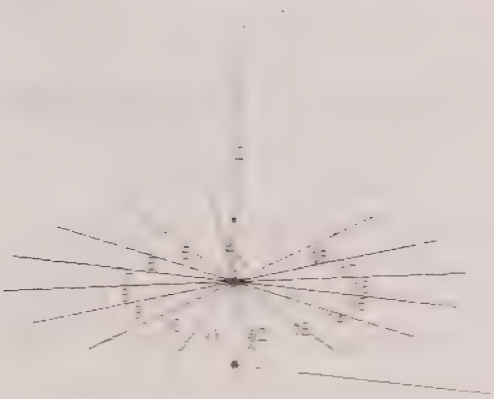


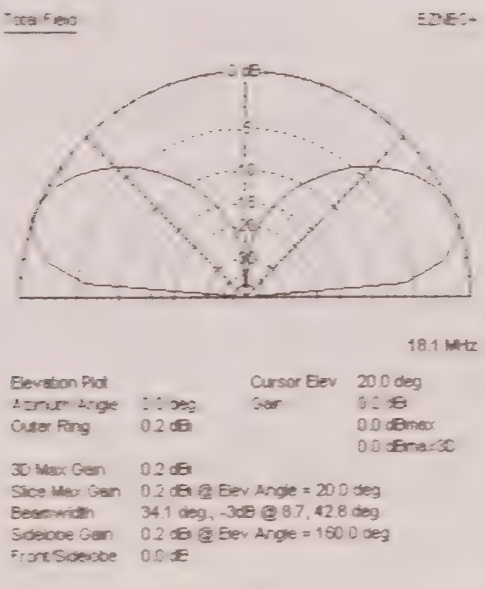


17m vertical with 4 radials

Far field plot for 17m with 4 radials

Figure 26 17m vertical antenna with 4 radials





17m vertical with 16 radials

Far field plot for 17m with 16 radials

Figure 27 17m vertical antenna with 16 radials

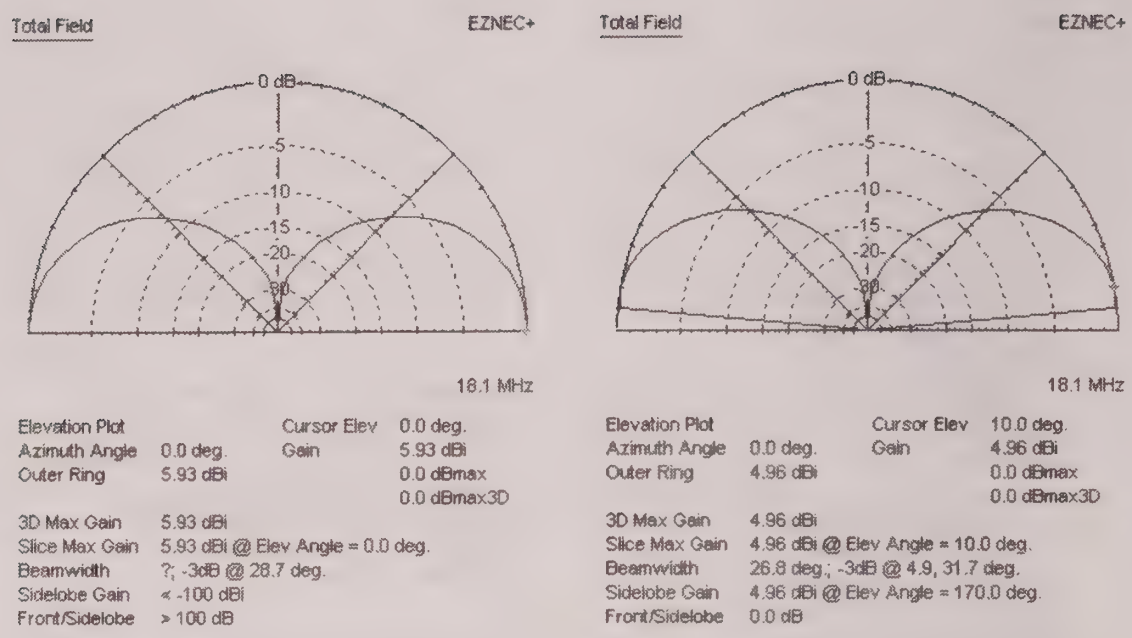
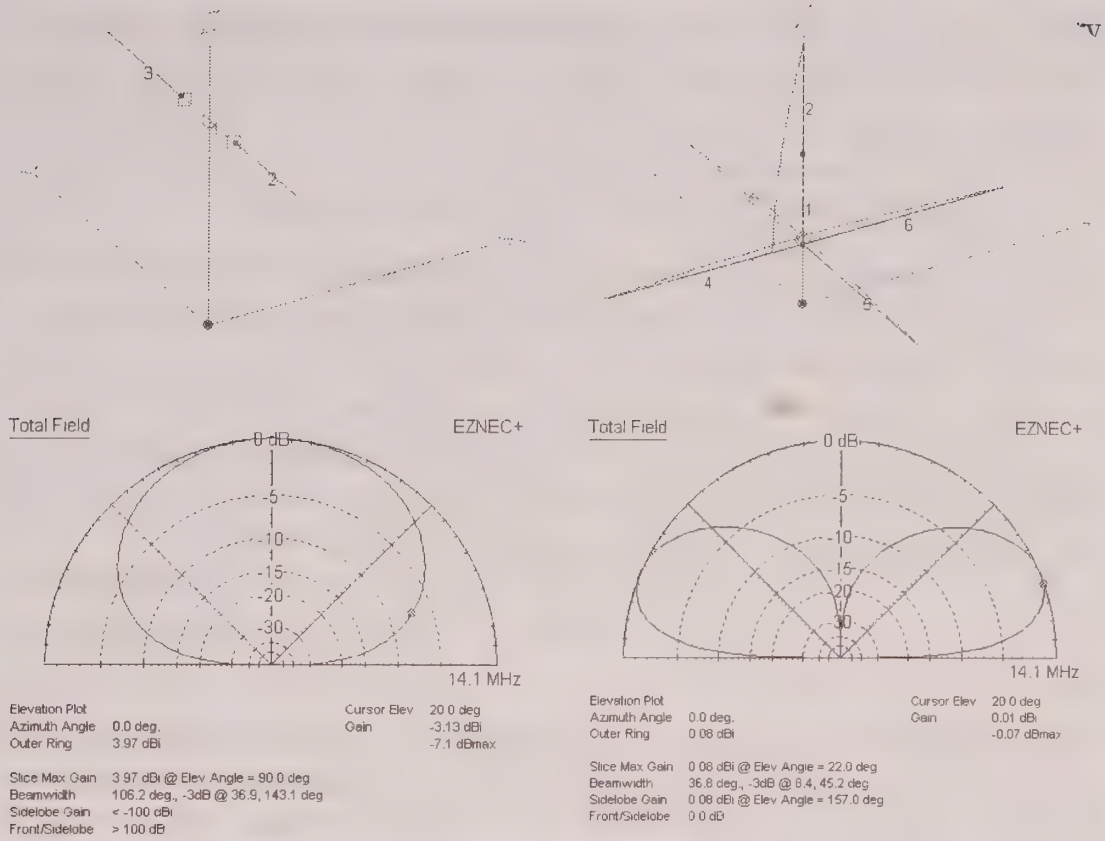


Figure 28 17m antenna deployed over *perfect* ground and saltwater

Consider the comparison of 20m antennas shown in Figure 29. The horizontal dipole is constructed from standard *Buddipole* parts using standard whips. The vertical antenna uses four arms and a long (9.5 foot) whip as the vertical element, and four wires for elevated radials. The vertical antenna is deployed at 5 feet.

One of the best accessories you can pack in your *Buddipole* bag is an extra pair of arms. They are very strong and enable the construction of full size antennas up to 20m with a 9.5 foot whip. Further, as later sections in the book will show, every inch of radiator in a shortened vertical antenna improves efficiency. You get that extra length with extra arms.

At the 20 degree elevation, the horizontal dipole has a gain of -3.13 dBi compared with the vertical's 0.01 dBi gain. And, remember, this 0.01 dBi figure for the vertical is over "average" ground. If we move it over saltwater it gets much better! (The dipole must be placed over "perfect" ground to come close to the gain the vertical has over "average" ground.) Just to put things into perspective, the vertical gives you a half an S-unit more power than the equivalent horizontal dipole over average ground, and more than an S-unit improvement near the beach. Add to these facts that the vertical is easier to construct and tune, faster to set up, and more stable in high winds than the horizontal dipole. The vertical configuration (with 2 or more radials) is a clear winner when the *Buddipole* is ground mounted.



20m horizontal dipole @ 8 feet **20m vertical with 4 radials @ 5 feet**

Figure 29 Comparison of 20m antennas horizontal versus vertical

In Table 7 the relative power outputs (dBi) for antennas at the 20 degree takeoff angle are compared. Deployments on an 8 foot mast will always see better performance from verticals. Deployments of dipoles on a 16 foot mast may be better than vertical configurations for bands down to 20m, but they are more difficult to construct, erect, and guy than vertical configurations.

Band	Dipole 8'	Dipole 16'	Vertical 8'
10m	1.0	5.8	1.7
12m	0.4	4.7	1.7
15m	-0.5	3.4	0.9
17m	-1.5	2.3	0.7
20m	-3.1	0.9	0.4
30m	-5.7	-0.8	-0.3
40m	-8.8	-2.8	-0.4

Table 7 Relative power outputs (dBi) at 20 degrees for various configurations

Total F

e may not be the final story as verticals deployed over or show significant gains over those listed here (that assumes ɔund). For bands 10m-15m, the dipole on a 16 foot mast is ɛ best choice, but it becomes much less clear for 17m and 20m. F ⁄0m and 40m, the vertical is the obvious choice.

There are a few final points that should be made before proceeding to the *cookbook* section. The typical feedpoint impedance for a horizontal dipole in free space is 70 ohms. A ¼ wave vertical is half a dipole and has half the impedance (something in the neighborhood of 35 ohms) when there are no other losses and when the antenna is full-sized. *Buddipole* verticals will have those extra losses through the ground as they will not be deployed over perfect ground. And, some *Buddipole* configurations will be smaller than full-sized antennas so the radiation resistance will be much lower than that of a full-sized antenna. Both affect feedpoint impedance.

If an antenna were to present 25 ohms impedance at the feedpoint, and our radio is expecting 50 ohms, then a 2:1 ratio transformer, matching the 25 ohm load to our radio, would be ideal. Or, if the antenna presented a 12.5 ohm load, then a 4:1 ratio transformer would match the load to the 50 ohms expected by the radio. Both translations are possible with the *Buddipole Triple Ratio Switched Balun* (TRSB).

Triple Ratio Switch Balun

The switch on the TRSB allows the user to select 1:1 (50 ohms to 50 ohms), 2:1 (50 ohms to 25 ohms), or 4:1 (50 ohms to 12.5 ohms). Verticals will often present less than 50 ohms at the feedpoint so this box is very handy for deploying vertical antennas.

There is another issue with vertical antennas worth discussing. Radial wires are wire elements that are connected to the "cold" side of the coax. The power runs down the coax traveling on the outside of the center conductor and the inside of the braid of the coax. The outside of the braid looks like a third conductor at HF frequencies. What keeps the power from just following the outside of the braid back to the radio?

The *Buddipole* standard coax (in either 25 foot or 50 foot lengths) has *beads* on the coax near the banana plug leads that help stop RF current

from traveling on the outside of the coax shield. These beads work very well at high frequencies. However, at low frequencies (such as 40m and below) the effectiveness of these beads is lessened.

The second major feature of the TRSB is an isolation transformer that keeps the RF off the outside of the coax, even at lower frequencies. These two features: the ability to match lower feedpoint impedances, and the isolation transformer keeping power off the outside of the coax, make the TRSB a must-have accessory for vertical antenna deployment.

Key accessories for ground mounted verticals are:

- Extra 22 inch arms
- Triple Ratio Switch Balun
- 9.5 foot whip
- Shock-cord mast
- Counterpoise Wire Adapters
- Radial wire kits
- Banana plug jumper wire

Selecting a full-sized antenna configuration is recommended wherever possible. Vertical antennas present a feedpoint impedance of roughly 35 ohms when they are full-sized and complemented with an effective radial system. Radiation resistance component of the feedpoint impedance drops quickly with radiator size. Figure 30 shows the relationship between the vertical antenna radiator length and the radiation resistance for a 40m vertical antenna.

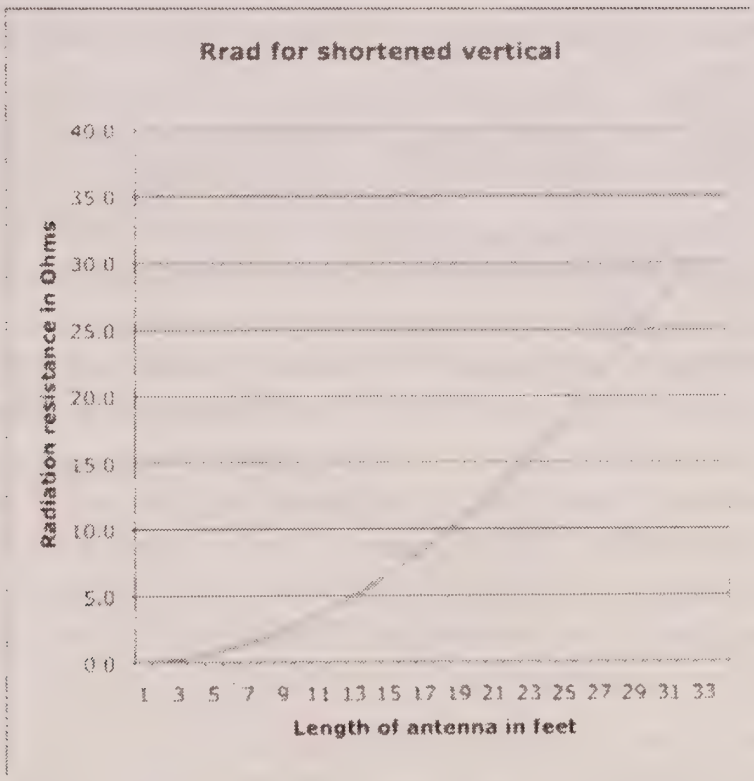


Figure 30 Radiation resistance for a 40m vertical versus height of antenna

Buddipole configurations cannot easily produce a vertical radiator longer than 20 feet. Figure 31 shows the radiation resistance values for a range of antenna heights from 1 foot to 20 feet for a 40m vertical antenna.

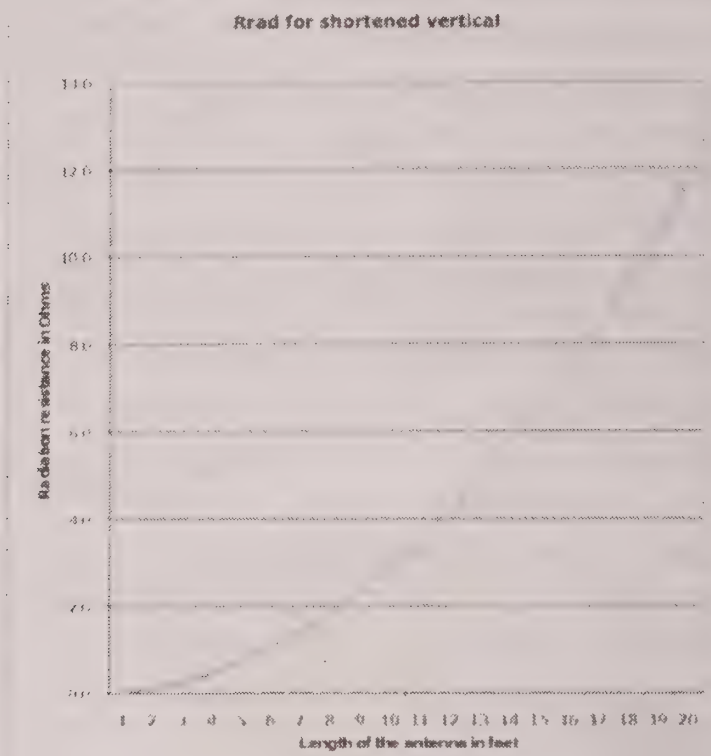


Figure 31 Radiation resistance for a 40m vertical from 1 to 20 feet in length

As the graph shows, every inch of radiator counts! Remember, it is radiation resistance that corresponds to the useful work of an antenna, and that radiation resistance is most closely attributed to the length of the radiator. The longer the radiator, the higher the radiation resistance will be, with the corresponding increase in antenna efficiency. Consider Table 8. The configuration is changed step-wise from just two arms and a short (5.5') whip to four arms and a 12 foot shock-cord whip. The length ranges from 8.7 feet to over 19 feet. Radiation resistance ranges from 2.2 ohms to 10.9 ohms. If we were to assume that an increase in radiation resistance would have a corresponding increase in radiated power (the relationship is more complex, but it is useful for this discussion to make such an assumption) then the difference between supplying just the minimum radiator (8.7 feet) and the maximum (over 19 feet) could be as much as an S-unit difference in output!

There are lots of assumptions in this discussion, but it points us in the right direction. Longer radiators mean higher radiation resistance, leading to more efficient antenna systems, producing more radiated power.

Length (feet)	Description	Rrad	% better than minimum	% better than previous
8.7	Two arms + short whip	2.2		
13.2	Two arms + BP long whip	5.1	129%	129%
15.0	Three arms + BP long whip	6.6	197%	30%
16.8	Four arms + BP long whip	8.3	274%	26%
19.3	Four arms + 12 foot whip	10.9	393%	32%

Table 8 Radiation resistance for a 40m vertical with varying configurations

Ideally, the antenna should have 50 ohms of radiation resistance to match the 50 ohms expected by the radio. An antenna with only a few ohms of radiation resistance, like a very short vertical, presents three problems:

1. The radio is expecting 50 ohms from the antenna system. If, for example, the antenna presents 12 ohms then the system will require an impedance transformer with a ratio of 4:1 to bring the impedance close to 50 ohms. The TRSB is ideal for this.
2. Losses such as ground losses, coax losses, inductive and capacitive reactance at the feedpoint reducing the current flowing through the system, all these components of the feedpoint impedance exist independently of the radiation resistance. As radiation resistance decreases it becomes a smaller component of the total feedpoint impedance. Antenna efficiency goes down when all these losses remain, and the radiation resistance is reduced.
3. Use of a transformer such as a TRSB set to the 4:1 ratio will amplify any swings of impedance as the frequency changes. This reduces the SWR 2:1 bandwidth. To see why a quick review of how SWR is computed is in order.

SWR is computed by the formula

$$SWR = \frac{1 + \left| \frac{Z_L - Z_0}{Z_L + Z_0} \right|}{1 - \left| \frac{Z_L - Z_0}{Z_L + Z_0} \right|}$$

where Z_L is the impedance of the load (the impedance presented by the antenna), and Z_0 is the 50 ohm impedance expected by the radio. (All

impedance values are *complex numbers.*) Consider the SWR for an antenna system that presents 35 ohms pure resistance (like a vertical with a very good ground system). The SWR for this antenna would be[4]

$$SWR = \frac{1+\left|\frac{35-50}{35+50}\right|}{1-\left|\frac{35-50}{35+50}\right|} = \frac{1+\frac{15}{85}}{1-\frac{15}{85}} = \frac{1.18}{0.82} = 1.43$$

That is, the SWR when 35 ohms is presented and the radio expects 50 ohms is 1:43:1. This is what you would expect from a quarter wave vertical at resonance. If the antenna impedance were to change to 30 ohms (a change of 5 ohms) then the SWR would become 1.67:1. A change of 5 ohms one way or another when the expected impedance is 50 ohms produces a small change in SWR. However, when the TRSB is put into the system reducing the expected impedance to 12.5 ohms (using the 4:1 setting) a difference of a few ohms can make a huge difference in the SWR. Consider the following table:

Impedance	SWR
4.0	3.1:1
9.0	1.4:1
12.5	1:1
20.0	1.6:1
40.0	3.2:1

The 2:1 SWR bandwidth of an antenna is the range of frequencies within a band where the antenna presents an SWR of 2:1 or less. In the case where the 4:1 impedance ratio of the TRSB is used, that range of feedpoint impedances is only 6 ohms to 25 ohms, a range of only 19 ohms. When the TRSB is set to the 1:1 ratio and the expected impedance is 50 ohms then the range of impedances that would be within the 2:1 SWR is 25 ohms to 100 ohms, a range of 75 ohms.

The SWR plots of the antennas in this chapter reflect how these ratios set in the TRSB affect the 2:1 SWR bandwidths of the antennas. More specifically, shorted verticals (those that are not full-sized), with lower radiation resistance values, and TRSB settings other than 1:1 will have smaller 2:1 SWR bandwidths when compared with the full-sized antennas. They will also be more "touchy" to tune (more difficult to

---

[4] Those vertical bars surrounding the fractions mean "magnitude" or "absolute value". That is, ignore the sign of the result. Treat it as a positive value.

configure to have a good SWR match to the radio), be more sensitive to nearby objects, and generally be more problematic in the field.

The *cookbook* section provides configuration information for antennas serving bands 10m through 40m. Configuration variations including TRSB settings are indicated for all antenna designs.

Finally, a discussion regarding radial systems is in order. Radial systems provide the "other half" of the antenna. The number, placement, and lengths of the radial elements can affect antenna performance and feedpoint impedance. Downward sloping radials can raise feedpoint impedance, for example.

Antenna configurations described in the *cookbook* section will also specify options for radial systems. Because the radial systems have significant effects on feedpoint impedance the TRSB settings are as dependent, or even more dependent, upon these factors as the configuration of the vertical element of the antenna.

All wire radial configurations (those not using whips) are four wires at the length and angle specified in the configuration, separated by 90 degrees. While similar results are expected with only two radials, four (or more) are strongly recommended—especially on bands 20m, 30m, and 40m, to reduce ground losses.

Buddipole Ground Mounted Verticals Cookbook

This chapter will cover ground mounted antennas from 10m through 40m. The configurations and bands discussed here will overlap with other chapters in the book such as *Buddipole on the beach* and *Low band antennas*. The general concepts and approaches are discussed here with refinements covered in those later chapters.

Figure 32 shows a typical deployment. The VersaTee, mounted on a mast, holds the vertical element and provides connection points for the radial wires. The feed line connects to the center/top tap (red/hot) and one of the side taps (black/shield). A Velcro strap holds the feed line securely to the mast.

All *Buddipole* vertical antennas should be mounted such that the feedpoint is elevated above the ground. Keeping the antenna (and radials) at least four feet above the ground significantly reduces ground losses.

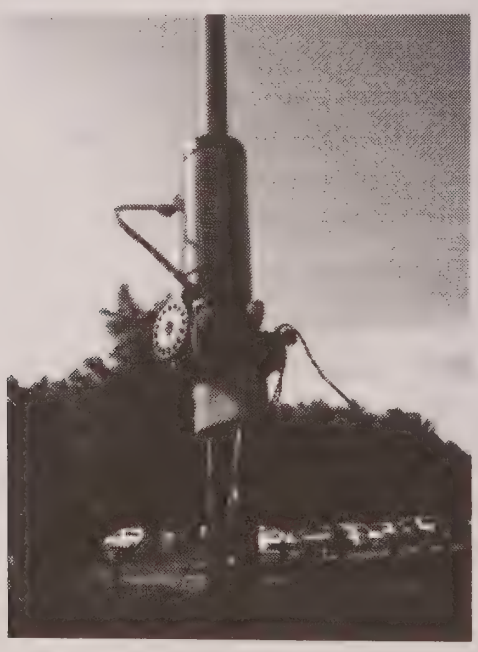
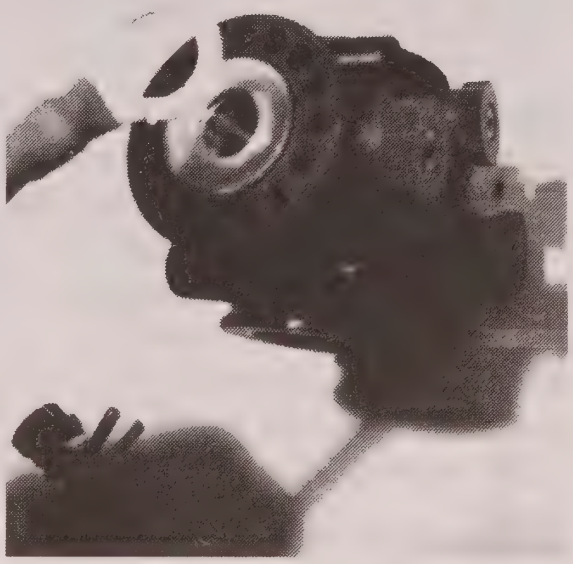


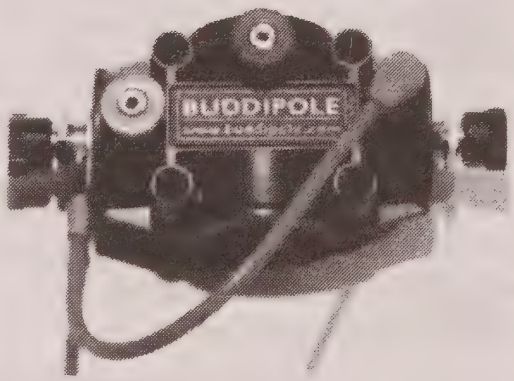
Figure 32 *Buddipole* vertical with radial wires and feed line

A single side of the VersaTee can be used for connecting radials, but it is more convenient to use both sides. Consider the following.

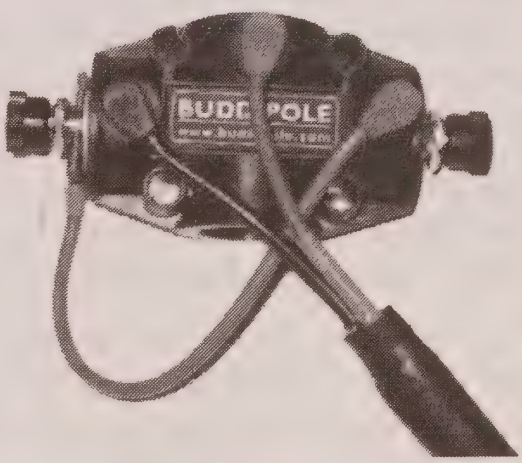
The VersaTee has three connection points: left, right, and center/top. The center/top is used for the vertical radiator leaving the left and right taps for the connections to the radials. Since the standard *Buddipole* feed line has only two connectors (red/hot and black/shield), one must run a jumper between the two horizontal taps if they are both to be used for connecting radials.



Buddipole, Inc. offers mini-banana plug leads on its accessory web page. These are used as wander leads for the coils, but they can also be used to construct a jumper between the left and right side of the VersaTee.

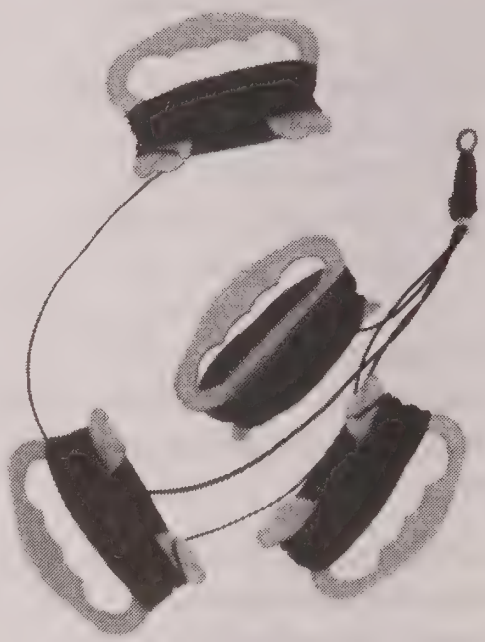


The best way to deploy radials from both sides of the VersaTee is to attach a banana plug jumper to one side of the VersaTee using a *Counterpoise Wire Adapter* (CWA), and plug the banana plug into the banana receptacle on the other side as shown. A second CWA can then be used for securing radials.



The ability to secure radials to both sides of the VersaTee makes deploying radials easier than using just one side. Regardless of where the radial wires are attached, there should be a minimum of two radials, and four radials are preferred. *Buddipole*, Inc. offers a radial wire kit,

terminated with a ring connector, and supplied with the CWA. You can also make your own kit using plastic kite string winders and lightweight wire. An excellent choice for wire is #534 "Invisible Toughcoat Silky 26 AWG copper-clad steel" wire from *The Wire Man* (http://www.thewireman.com). This wire is very strong, yet very light. The vendor claims the wire is less than 1 pound per 1000 feet! The wire is very flexible and wraps easily on plastic winders. Four radials approximately 40 feet each (as shown) weigh only a few ounces.



Four radial wires terminating in a single ring connector. (Assembly made by the author.)

The plastic winders (purchased separately from a kite hobby store) are convenient because they often have a small slot that will hold the wire in place to prevent further unraveling. This slot is a quick way to both secure the wire for storage and to secure the wire at a desired length when deployed.

To deploy radials, affix the ring connector to the CWA on the VersaTee. Walk each radial out one-by-one to the desired length and secure it to the winder using either the slot (if available), a Velcro strap, or some other means. *Ensure that the radials are at least 2 feet above the ground and higher if possible.* Elevated radials are only effective if they are elevated.

The portion of the wire rolled out will be the only wire "seen" by the antenna. Any wire left on the winder will be "invisible" and not affect antenna performance or tuning.

These antenna configurations assume that the antenna is deployed at 8 feet (the VersaTee is mounted on a mast 8 feet above the ground) and that wire radials are sloping down from the VersaTee to a point no lower than 2 feet above the ground. For radials (horizontal elements) made from whips, possible for the higher bands, those radials are assumed to be parallel to the ground unless the *Rotating Arm Kit* is employed.

10m vertical

The standard *Buddipole* kit contains enough parts to create a vertical element for a full-sized 10m antenna. The addition of 9.5 foot whips enables more configuration options. The longer whips can be used as part of the vertical element, or they can be used as radials.

If a 16 foot mast is available, a horizontal dipole configuration should be considered. See the chapter *Balconies and Rooftops* for specifications for that alternative.

Standard *Buddipole*

Optional RAK 9.5' whip

Vertical element

Option 1:
- 5.5' whip: 5 sections (56 inches)
- Two accessory antenna arms

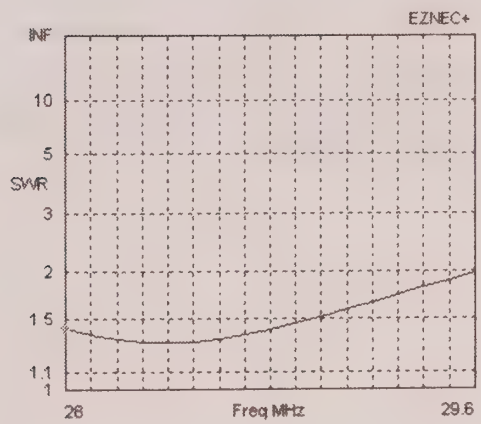
Option 2:
- 9.5' whip: 99 inches

Radials

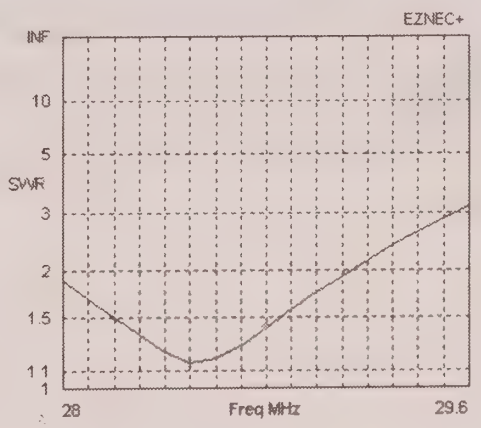
Option 1:
- Wire: 8 feet 4 inches sloping from 8' to 4'
- TRSB 1:1

Option 2:
- Whips: 9.1 feet (111 inches) @ 90 degrees
- TRSB 2:1

Option 3:
- Whips: 8 feet 4 inches sloping down 20 deg
- [Requires RAK]
- TRSB 1:1



SWR with sloping radials



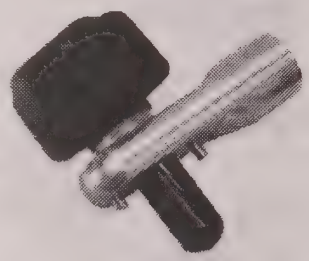
SWR with horiz. whip radials

Figure 33 SWR plots for 10m vertical

The downward sloping wire radials raise the feedpoint impedance enough that the antenna provides a good match across the entire band.

The whip radials mounted directly into the VersaTee are easy and quick to deploy, but the impedance of this antenna configuration is only about 25 ohms. Hence, the TRSB should be used at the 2:1 setting (matching the 25 ohms to the radio's 50 ohms) with horizontal whip radials.

An alternative to horizontal whip radials is to use the *Rotating Arm Kit* (RAK) to angle the radial whips down like the wire radials were sloped. This combines the convenience of using the whips for the radials and the benefits of sloping radials that increase feedpoint impedance. To attach the RAK element to the VersaTee, remove the soft rubber cover from the threaded bolt. Align the pins on the aluminum RAK piece with the desired holes in the VersaTee and secure with the bolt. Do not over-tighten. The pins on the aluminum piece will hold the piece in place. Adjust the knob so that the connection is finger tight.



Rotating Arm Kit element

The threaded portion of the RAK aluminum piece should angle down from the side of the VersaTee at a 20 or 30 degree angle from the horizon. Note that the small jumper used to make an electrical connection between the two sides of the VersaTee must be installed to use both sides of the VersaTee for radials. The ring of the jumper should fit between the pins of the RAK element.

These settings assume deployment over flat terrain, over "average" ground, and away from any objects that would interact with the near field of the antenna. If a good match (low SWR) is not achieved immediately from these settings try extending or retracting the radials in one inch increments to bring the feedpoint impedance closer to 50 ohms.

12m vertical

The 12m antenna is much like the 10m antenna system except that the fully extended short whip and two arms on the are just a little short. However, even with the short whip the antenna will still provide a sufficiently close match for the radio.

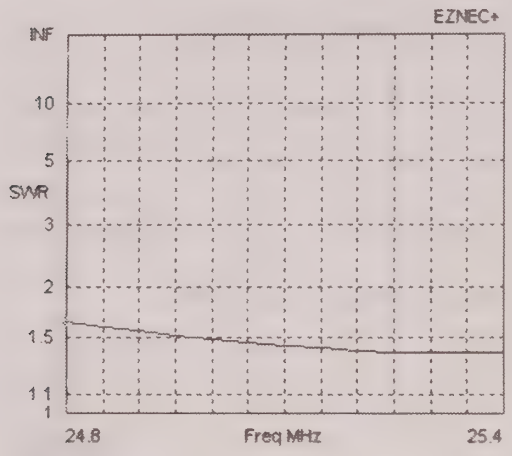
If a 16 foot mast is available a horizontal dipole configuration should be considered. See the chapter *Balconies and Rooftops* for specifications for that alternative.

Standard Vertical element
Buddipole Option 1:
5.5' whip: 6 sections (all out)
Optional Two antenna accessory arm
RAK (This configuration is a little short.
9.5' whips Adjustments to the radials aid the matching.)
+2 arms Option 2:
9.5' whip: 6 sections (all out)

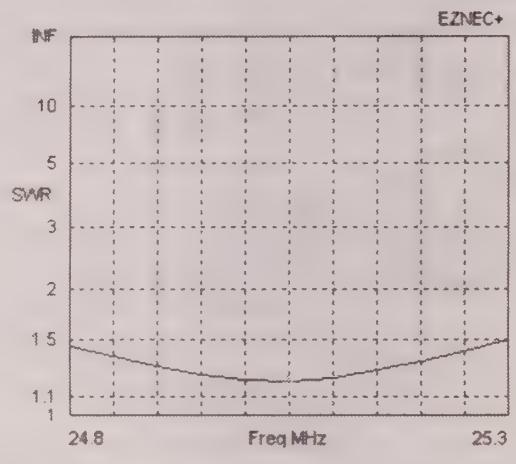
Radials
Option 1:
Wire: 9.4 feet (113) inches sloping from 8' to 4'
TRSB 1:1
Option 2:
Antenna accessory arm (22")
Whips: 9.5 feet (114 inches) @ 90 degrees
TRSB 2:1
Option 3:
Whips: 9.4 feet (113 inches) sloping down 20 degrees
[Requires RAK]
TRSB 1:1

Standard	Vertical element
Buddipole	5.5' whip: 6 sections (all out)
with coil	Two antenna accessory arm
	Red coil: tap 2
Optional	
RAK	Radials
9.5' whips	See above
+2 arms	

The radiator and radials for the 12m band are almost exactly the size of a 9.5' whip so these longer pieces are ideal for this configuration.



SWR with sloping radials



SWR with horiz. whip radials

Figure 34 SWR plots for 12m vertical

The radial system has a significant impact on the impedance presented by the antenna. Radials that slope down away from the antenna raise the feedpoint impedance to something close to 50 ohms, close enough to that value that a TRSB should be set to the ratio 1:1. Conversely, the horizontal radials not only present a lower feedpoint impedance (something close to 20 ohms), but they must be much longer to obtain a good match. This extra length is achieved by the addition of an antenna accessory arm on each side between the 9.5' whip and the VersaTee. The TRSB should be set to the ratio 2:1 (matching the roughly 25 ohms to 50 ohms) for horizontal radials.

The third option for radials (sloping whips) requires the RAK. See the description for the 10m antenna for additional details for deploying sloping radial whips.

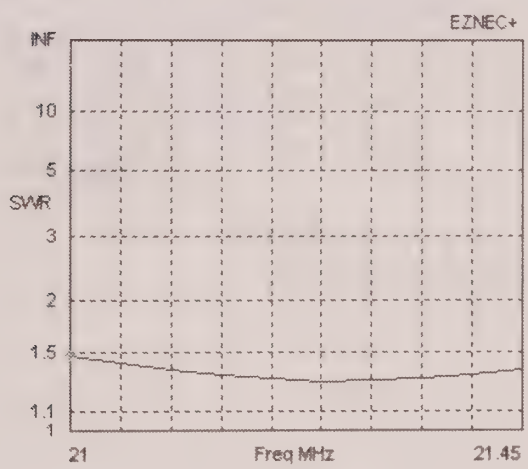
15m vertical

It is preferable to create full-sized antennas (those without loading coils) rather than loaded, shortened verticals. For bands 15m and down the parts complement of a standard *Buddipole* package are insufficient to build full-sized antennas. Either the antenna must be loaded, or additional parts must be supplied.

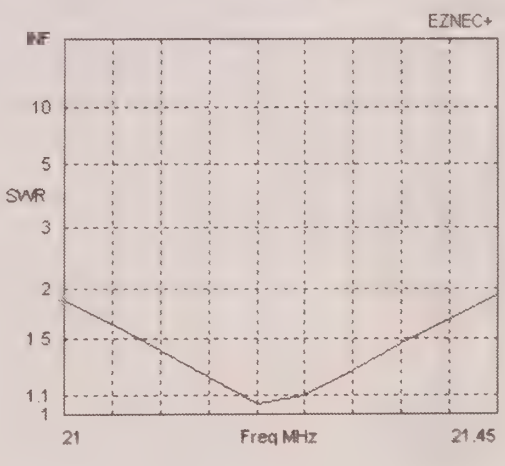
If a 16 foot mast is available a horizontal dipole configuration should be considered. See the chapter *Balconies and Rooftops* for specifications for that alternative.

Standard	Vertical element
Buddipole	Standard 5.5 foot whip: 6 sections (all out)
	Red coil: tap 3
Optional	One antenna accessory arm
RAK	
9.5' whips	Radials
+2 arms	Option 1:
	Wires: 12 feet (144) inches sloping from 8' to 3'
	TRSB 2:1
	Option 2:
	2 arms (@ 22" ea)
	Whips: 7.8 feet (94 inches) @ 90 degrees
	(Total of 137 inches of radial length)
	TRSB 4:1

The SWR plots for the two radial options appear below in Figure 35.



SWR with sloping radials



SWR with horizontal whip radials

Figure 35 SWR plots for 15m vertical

The antenna is short for a 15m antenna. The resulting capacitive reactance is cancelled by three turns of the red coil as indicated.

Additional configuration options yielding full-sized (or near full-sized) antennas are specified below. As always, full-sized antennas are preferred to shortened verticals with coil loading.

Standard *Buddipole* 3 arms

Optional RAK 9.5' whips +2 arms

Vertical element

5.5 foot whip: 6 sections (all out)
Three antenna accessory arm
(This configuration is a little short. Adjustments to the radials aid the matching.)

Radials

See above
It might be helpful to extend the radial wires a few inches longer in this configuration.

Standard *Buddipole* Long whip

Optional RAK 9.5' whips +2 arms

Vertical element

Long 9.5 foot whip: 6 sections (all out)
One antenna accessory arm

Radials

See above

17m vertical

The 17m WARC band is small enough (only 100 kHz wide) that it is relatively easy to tune the antenna to cover the whole band with less than 2:1 SWR. Replacing the 5.5' whip with a 9.5' whip provides an opportunity to create a full-sized antenna with just two accessory antenna arms.

If a 16 foot mast is available a horizontal dipole configuration should be considered. See the chapter *Balconies and Rooftops* for specifications for that alternative.

Standard *Buddipole*

Vertical element

Standard 5.5 foot whip: 6 sections (all out)
Red coil: tap 5
Two antenna accessory arm

Radials

14.25 feet (170 inches) sloping from 8' to 3'
TRSB 2:1

Standard *Buddipole* 4 x arms

Vertical element

Buddipole 5.5 foot whip: 6 sections (all out)
Four antenna accessory arm
(This configuration is a little short. Adjustments to the radials aid the matching.)

Radials

14.25 feet sloping from 8' to 3'

Standard *Buddipole* **Long whip**

Vertical element

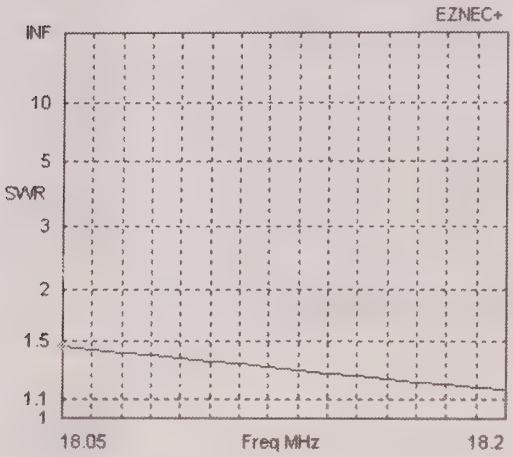
Long 9.5 foot whip: 5.5 sections (all out minus 3 inches)

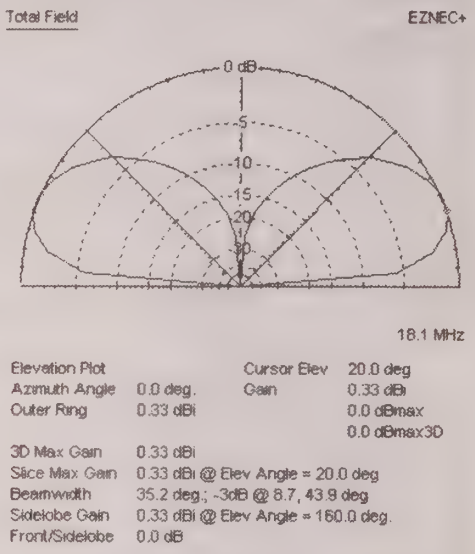
Two antenna accessory arm

Radials

14.25 feet sloping from 8' to 3'

The SWR and far field plot appear below in Figure 36.





SWR for 17m **Far Field Plot**

Figure 36 SWR and far field plots for 17m vertical

20m vertical

The standard *Buddipole* parts with its 5.5' whip and two arms create a vertical element only 110 inches high. This shortened vertical element will normally present less than 11 ohms of radiation resistance. Dropping the radials from 8 feet to 3 feet brings this value up a few ohms, but the system will still require the TRSB at the 4:1 setting to match the 50 ohms expected by the radio.

Standard *Buddipole*

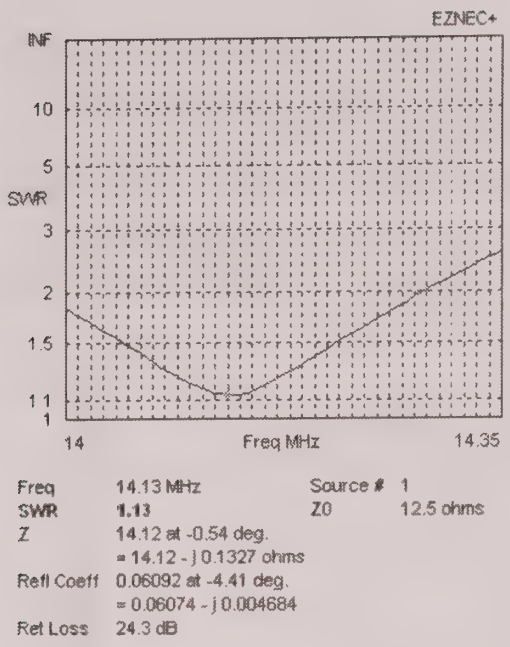
Vertical element

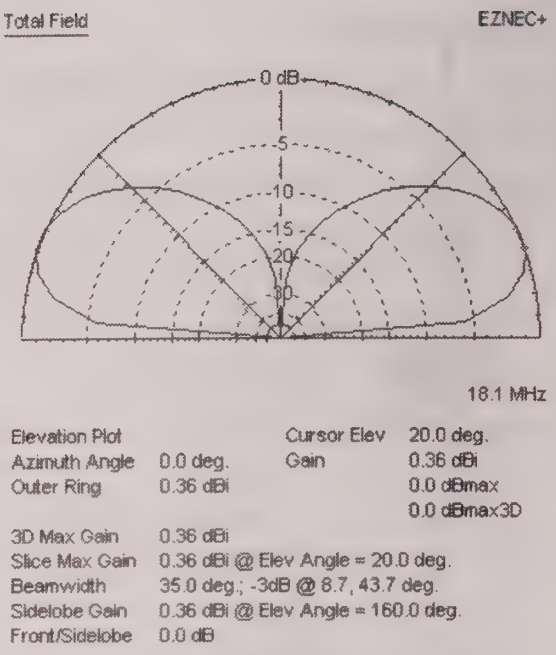
Standard 5.5 foot whip: 6 sections (all out)
Red coil: tap 9
Two antenna accessory arm

Radials

14 feet 1 inch sloping from 8' to 3'
TRSB: 4:1

This configuration provides about 190 kHz of 2:1 SWR bandwidth. Matching antennas with such a low radiation resistance is always tedious. To tune the antenna, increase or decrease radial lengths by a few inches in order to raise or lower the resonant frequency. Remember that the goal of tuning is to bring the antenna to resonance (making any reactive components cancel), not to bring the SWR to 1:1.





SWR plot for shortened vertical **Far field plot for 20m vertical**

Figure 37 SWR and far field plot for 20m vertical

It is always desirable to create a full-sized antenna versus a shortened one. The 20m band is the lowest band where this is possible and it requires either four accessory antenna arms, or 12 foot shock-cord whip. Either the standard coax assembly can be used, or the TRSB at the 1:1 setting can be used to feed this antenna. Unlike the shortened version above, this full-sized vertical will provide 2:1 SWR bandwidth across the entire 20m band.

Standard Vertical element
Buddipole Option 1:
Long 9.5 foot whip: 6 sections (all out)
Optional Four antenna accessory arm
Four arms Option 2:
Long whip 12 foot whip
12' whip Two accessory antenna arms

Radials
17 feet sloping from 8' to 3'

30m vertical

A 30m vertical antenna using only the 5.5' whip and two arms will produce a vertical element that is very short for this band. The radiation resistance for this antenna will only be a few ohms (around 5-7 ohms, depending on the radial configuration). Tuning will be touchy, but the band is only 50 kHz wide so even an antenna this short will have a 2:1 SWR bandwidth wide enough to cover the whole band. Even so, a TRSB with a 4:1 setting will need to be used to match this very low feedpoint impedance to the radio.

Standard ***Buddipole***

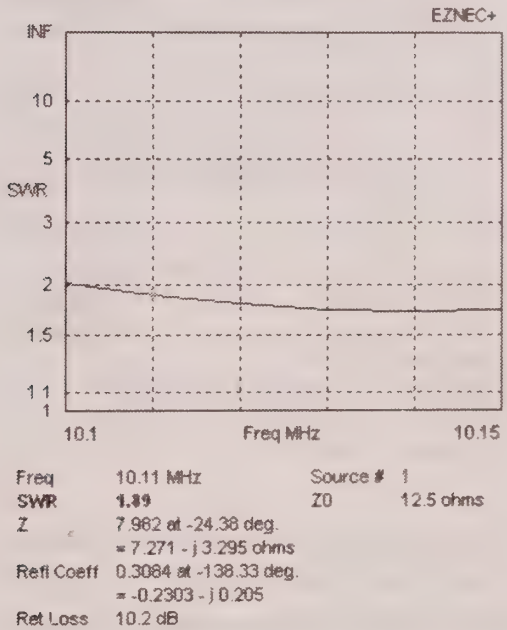
Vertical element

Standard 5.5 foot whip: 6 sections (all out)
Red coil: tap 16
Two antenna accessory arm

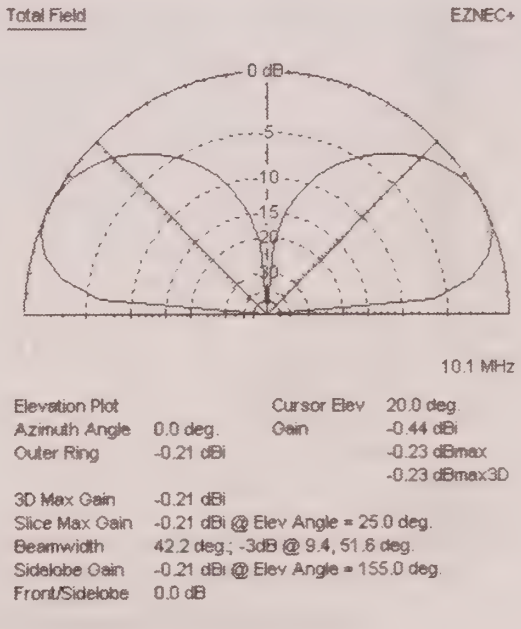
Radials

Wire: 250 inches sloping 8' to 3'
TRSB: 4:1

The far field plot shows that this antenna has a slightly higher average takeoff angle than those of higher bands with similar construction.



SWR plot for shortened vertical



Far field plot for 30m vertical

Figure 38 SWR and far field plot or a 30m vertical

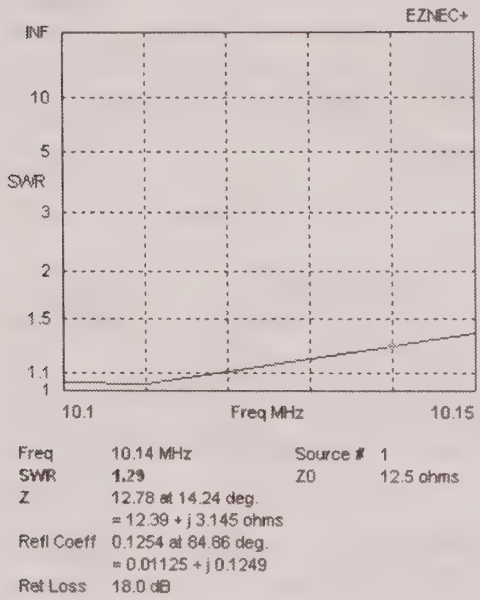
Just replacing the 5.5' whip with the longer 9.5' whip helps tremendously bringing the feedpoint impedance up from about 5 ohms to over 12 ohms. The TRSB at 4:1 is still required to achieve a good match but the longer whip reduced the number of coil turns necessary from 16 to 12, slightly reducing losses in the coil, but more importantly it makes the antenna easier to tune in the field.

Standard *Buddipole*
9.5' whip

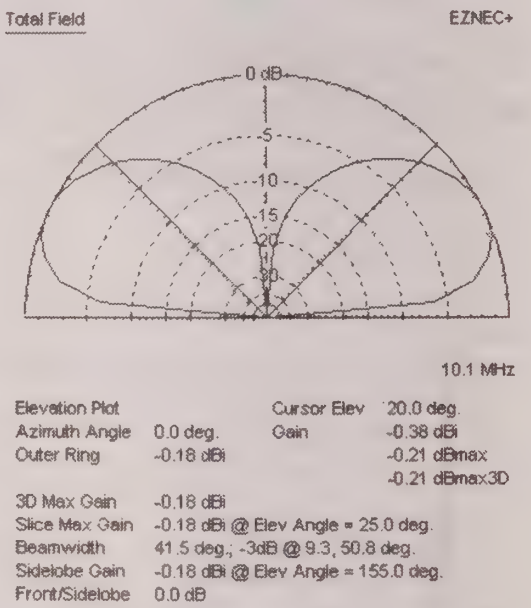
Vertical element
Buddipole 9.5 foot whip: 5.5 sections (110 inches)
Red coil: tap 12
Two antenna accessory arm

Radials
Wire: 20 feet sloping 8' to 3'
TRSB: 4:1

The SWR and far field plots for the configuration using the longer whip appears below.



SWR plot for shortened vertical



Far field plot for 30m vertical

Figure 39 SWR and far field plot for a longer 30m vertical

Adding the longer whip increased the length of the radiator. An additional arm (22 inches) in the system also helps. How much? It reduces the number of coil taps necessary by 2 (to only 10), further

reducing coil loss. It also added a couple of ohms to the radiation resistance.

Standard
Buddipole

3 arms
9.5' whip

Vertical element
Buddipole 9.5 foot whip: 6 sections (all out)
Red coil: tap 10
Three antenna accessory arm

Radials
Wire: 20 feet sloping 8' to 3'
TRSB: 4:1

It is also possible to add a much longer whip in addition to the extra antenna accessory arm. The configuration below uses the 12 foot shock-cord whip instead of the 9.5' whip. With the longer whip two more taps come off the total (now only requiring 8 turns) and the radiation resistance has risen to the point where the TRSB must only be set to 2:1.

Standard
Buddipole

3 arms
12' whip

Vertical element
12 foot whip
Red coil: tap 8
Three antenna accessory arm

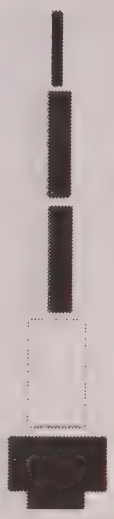
Radials
Wire: 20 feet sloping 8' to 3'
TRSB: 2:1

Adding a fourth antenna accessory arm creates a system similar to the one above except you should reduce the coil setting to tap 7.

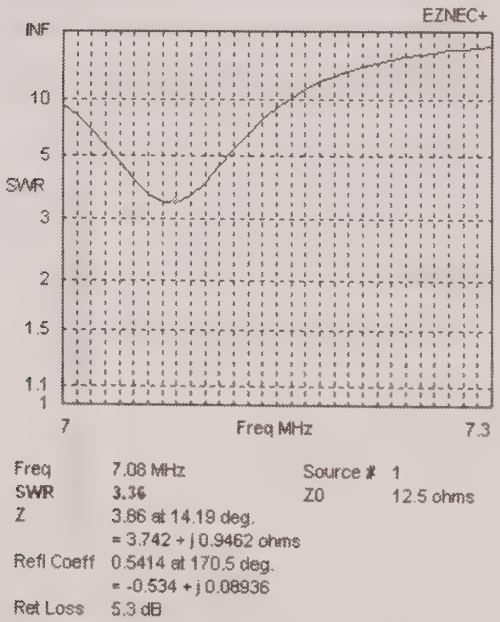
40m vertical

A 40m vertical antenna using only the 5.5 foot whip and two arms will produce a vertical element that is very short for this band. The radiation resistance will only be a few ohms. Tuning will be extremely touchy, and the best that can be done is a match where the SWR dips into the low 3's (even with the TRSB at 4:1).

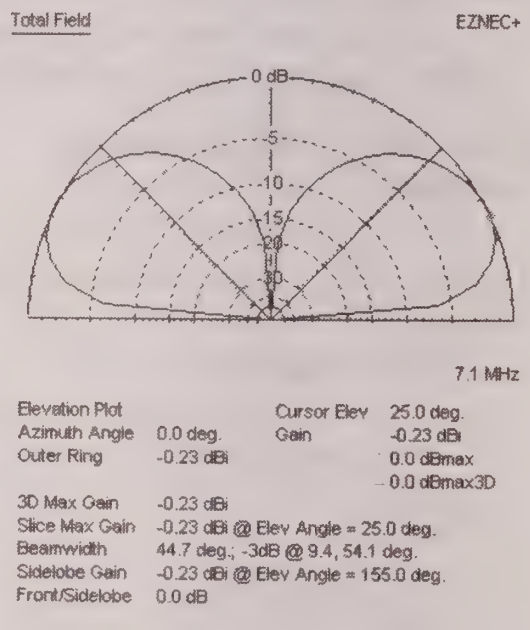
Standard	Vertical element
Buddipole	Standard 5.5 foot whip: 6 sections (all out)
TRSB	Two antenna accessory arm Red coil: tap 29
	Radials 25 feet (300 inches)



The plots below illustrate the problems with an antenna so short.



SWR plot for 40m vertical



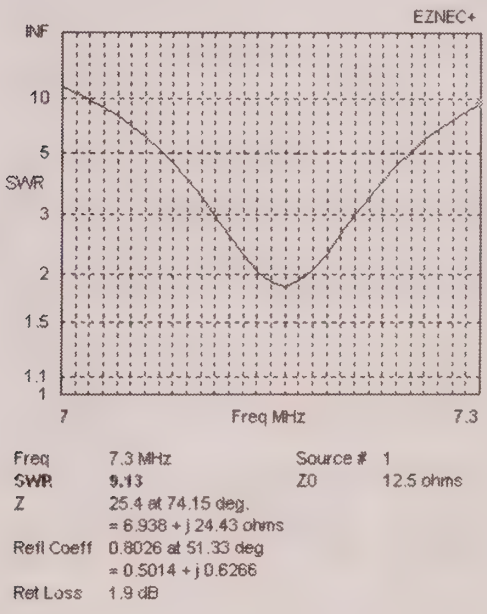
Far field plot for 40m vertical

Figure 40 SWR and far field plot for a 40m vertical

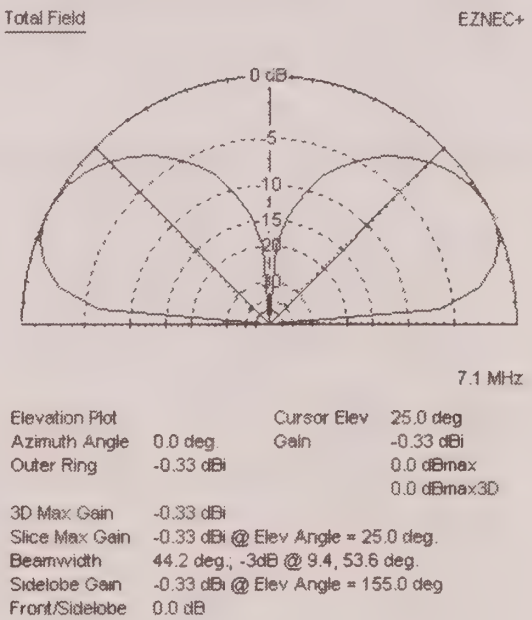
A *Buddipole* can be used to make effective 40m vertical antennas but the system must incorporate a longer radiator. The radiator can be lengthened either by adding a longer whip, adding more arms, or both.

Standard	Vertical element
Buddipole	*Buddipole* 5.5 foot whip: 6 sections (all out)
4x arms	Four antenna accessory arm
TRSB	Red coil: tap 23
	Radials
	25 feet (300 inches)

An antenna with four arms and a 5.5' whip produces a radiator 154 inches in length and an expected radiation resistance of about 5 ohms. This is still very short for a 40m antenna but represents a significant improvement over the two arm version.



SWR plot for 40m vertical



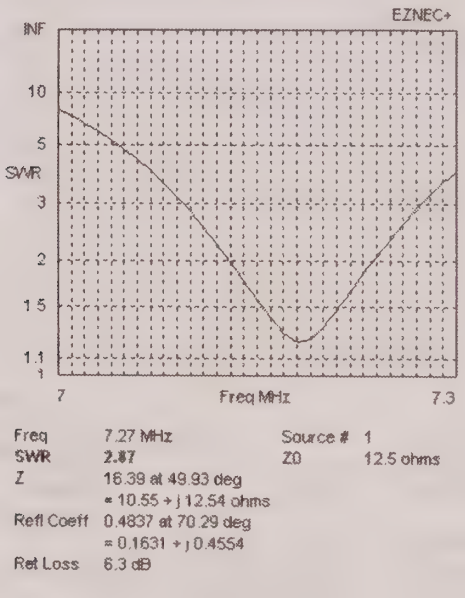
Far field plot for 40m vertical

Figure 41 SWR and far field plot for a longer 40m vertical

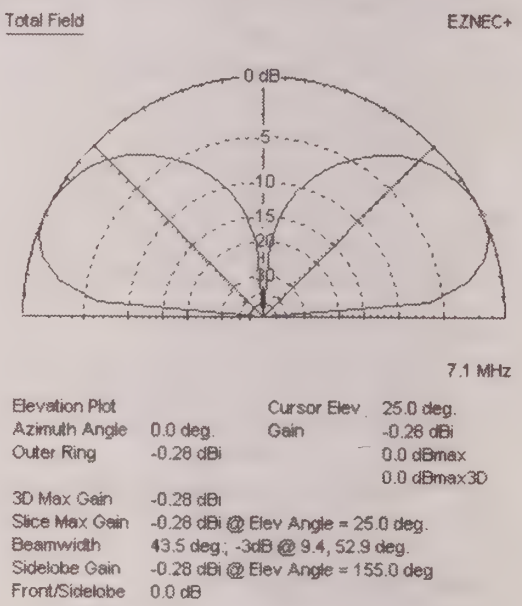
This antenna provides about 100 kHz of 3:1 SWR bandwith. Extending or retracting the radials can move the center frequency.

Standard	Vertical element
Buddipole	9.5 foot whip: 6 sections (all out)
	Four antenna accessory arm
4x arms	Red coil: tap 18
9.5' whip	
TRSB	Radials
	25 feet (300 inches)

The above configuration provides a 202 inch radiator which is expected to present about 8 ohms of radiation resistance. This extends the 3:1 SWR bandwidth to about 170 kHz (over half the band).



SWR plot for 40m vertical



Far field plot for 40m vertical

Figure 42 SWR and far field plot for a 200+ inch radiator 40m vertical

Finally, a radiator with four arms and the 12 foot shock-cord whip has an expected radiation resistance of about 11 ohms. Use coil tap 16. The 3:1 SWR bandwidth for this configuration is over 200 kHz.

7 *Buddipole* on the Beach

One of the best places to operate the *Buddipole* is from a beach along the ocean. While ground losses sap our power when we deploy over average terrain, the extremely conductive saltwater of the ocean reduces those losses and gives us that power back. Chris Drummond, President of *Buddipole*, Inc. calls this effect a *saltwater amplifier*. While there was no "amplification" involved, we do get an S-unit back under some circumstances!

Chris Drummond, W6HPF, with a *Buddipole* vertical

There have been many studies, formal and informal, regarding the best antenna configuration for deployment along saltwater. The answer keeps coming up vertical. Luckily, vertical antennas are the lightest and most easily erected configuration for the *Buddipole*. This chapter discusses configuration options for deployment along saltwater, especially right on the beach. A set of comparison far field plots between "average ground" and saltwater will be shown for each band so that the improvement in performance by moving to the sea can be fully appreciated.

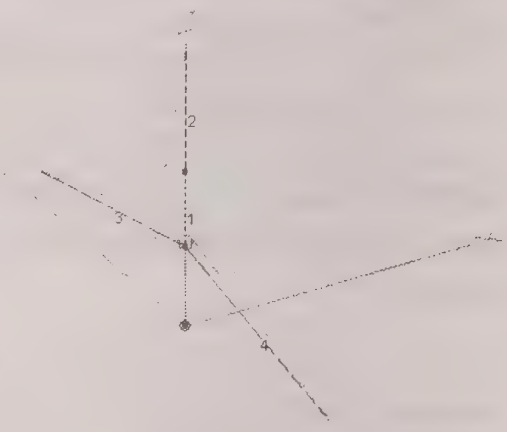
There are three good options for erecting the vertical on the beach. The standard *Buddipole* tripod and mast system work well on the beach, though they are a bit heavy for the job. A lighter alternative is to use a painter's pole with the *Painter Pole Adapter* and simply sink the painter's pole into the sand a foot or two. Guying the system with a couple of cords and a rock or piece of driftwood is usually all that is necessary to keep this pole erect. The third option is to use one of the *Buddipole*, Inc. shock-cord masts. These masts come in two sizes, 8 foot and 11 foot, fold down small, are very strong, and weigh only about a pound. The 8 foot mast is ideal for this deployment option. Just assembly the mast, sink it into the sand about a foot or two, guy it, and the top of the mast can be reached easily so you can affix the VersaTee and antenna element components. Use the Rotating Arm Kit (RAK) to build the element at eye level, then swing it to the vertical position when finished.

How effective are these antenna systems? An article in the *National Contest Journal* [July/August 2005] by Al Christman, K3LC, entitled *Vericals by the Sea* had these conclusions:

An elevated vertical monopole with two gull-wing radials makes an effective DX antenna when installed at or near a large body of saltwater. Compared to land, the high conductivity of this liquid medium yields enhanced signal strength at low take-off angles, with a resulting forward lobe that is broad in both the elevation and azimuthal planes. The height of the horizontal portions of the radials need not be great (typically on the order of a few feet), and the set-back distance from shoreline to antenna can range from zero to 0.25 wavelength, with little change in performance. This is good news for those who operate in locations with significant tidal action.

The *Buddipole* on a saltwater beach is configured just like the ground mounted *Buddipole* except the number of radials is less critical. Ground losses are minimized by the very conductive saltwater. In the following pages far field plots (including gain and takeoff angles) are shown for a given antenna over average ground, and one on a saltwater beach. The antenna on "average ground" has four elevated radials; the antenna on the beach has only two, parallel to the sea.

Typical 4 radial system over "average ground"



Typical 2 radial system on a saltwater beach

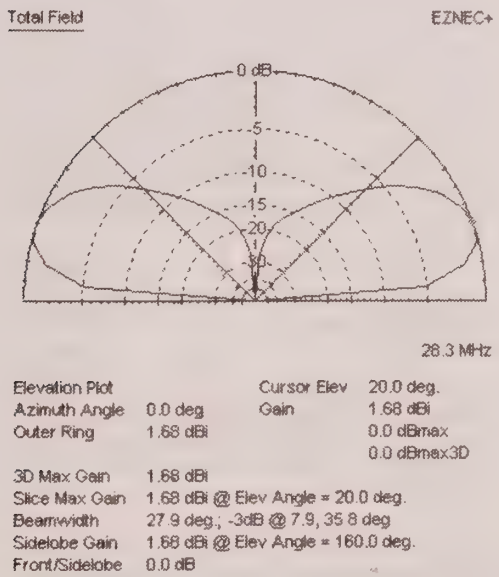
Keep the radials up, parallel to the sea, and close to the water, and enjoy the increased performance from the *Buddipole* vertical.

Buddipole Beach Antenna Cookbook

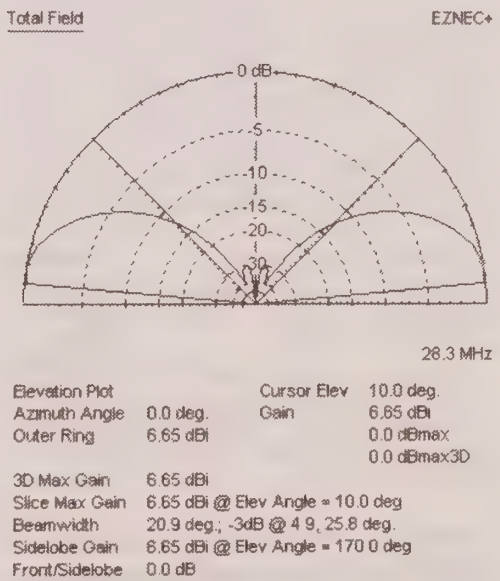
The configurations are identical for the beach verticals and ground mounted verticals. Radiator lengths, coil settings, and other setup information does not change just because we move closer to the water. Similarly, the guidelines and caveats for ground mounted antennas also apply. For best performance, use a full-sized vertical radiator. If a full-sized radiator is not possible, make the radiator as long as you can. Losses from inductive or capacitive reactance, losses through coils, reduced radiation resistance, and poor matching to the 50 ohms expected by the radio can reduce current and therefore power in the antenna system.

The following plots compare the best configurations for each band deployed over average ground and the waterline of the beach. As seen in the comparisons, antenna gain increases significantly (resulting from reduced ground losses), and the takeoff angle drops by the saltwater.

10m

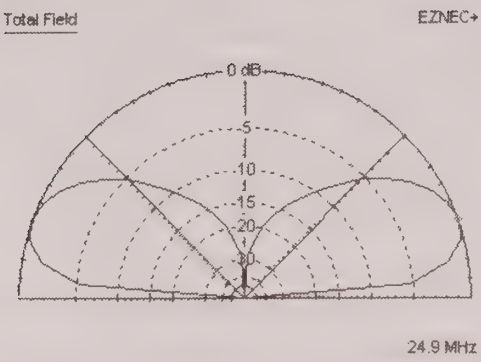


Far field plot for 10m antenna over average ground



Far field plot for 10m antenna on the beach

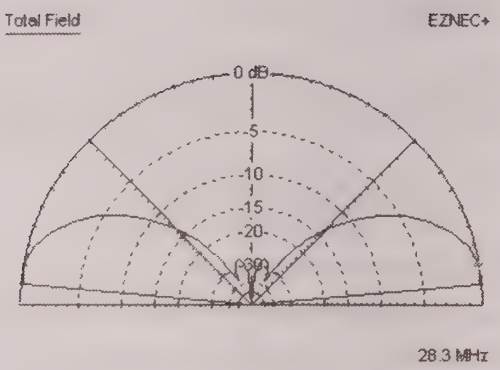
12m



24.9 MHz

Elevation Plot		Cursor Elev	20.0 deg.
Azimuth Angle	0.0 deg.	Gain	1.55 dBi
Outer Ring	1.55 dBi		0.0 dBmax
			0.0 dBmax3D
3D Max Gain	1.55 dBi		
Slice Max Gain	1.55 dBi @ Elev Angle = 20.0 deg.		
Beamwidth	29.7 deg.; -3dB @ 8.2, 37.9 deg.		
Sidelobe Gain	1.55 dBi @ Elev Angle = 160.0 deg.		
Front/Sidelobe	0.0 dB		

Far field plot for 12m antenna over average ground

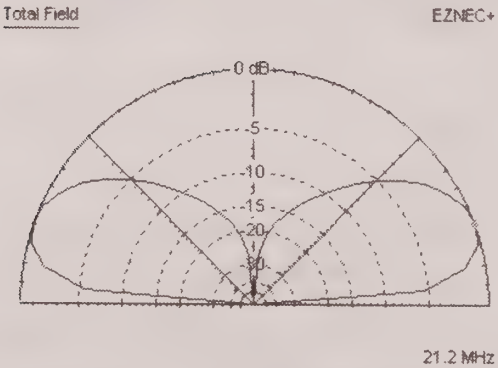


28.3 MHz

Elevation Plot		Cursor Elev	10.0 deg.
Azimuth Angle	0.0 deg.	Gain	6.85 dBi
Outer Ring	6.85 dBi		0.0 dBmax
			0.0 dBmax3D
3D Max Gain	6.85 dBi		
Slice Max Gain	6.85 dBi @ Elev Angle = 10.0 deg.		
Beamwidth	20.4 deg.; -3dB @ 4.9, 25.3 deg.		
Sidelobe Gain	6.85 dBi @ Elev Angle = 170.0 deg.		
Front/Sidelobe	0.0 dB		

Far field plot for 12m antenna on the beach

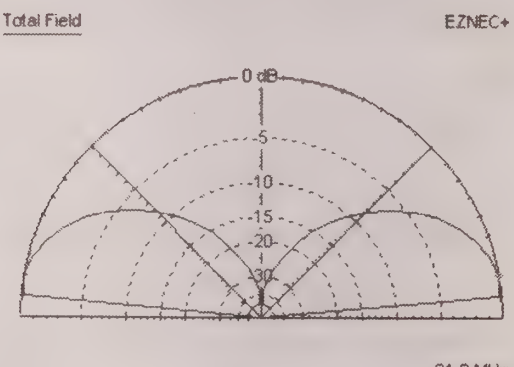
15m



21.2 MHz

Elevation Plot		Cursor Elev	20.0 deg.
Azimuth Angle	0.0 deg.	Gain	0.89 dBi
Outer Ring	0.89 dBi		0.0 dBmax
			0.0 dBmax3D
3D Max Gain	0.89 dBi		
Slice Max Gain	0.89 dBi @ Elev Angle = 20.0 deg.		
Beamwidth	30.3 deg.; -3dB @ 8.2, 38.5 deg.		
Sidelobe Gain	0.89 dBi @ Elev Angle = 160.0 deg.		
Front/Sidelobe	0.0 dB		

Far field plot for 15m antenna over average ground

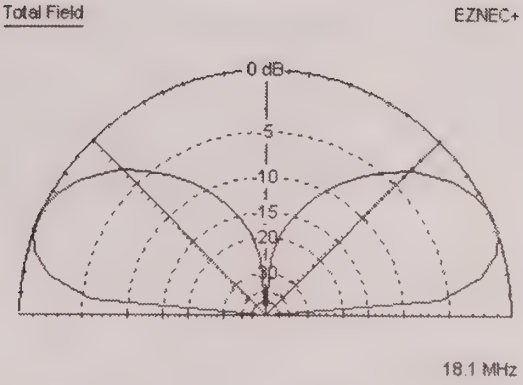


21.2 MHz

Elevation Plot		Cursor Elev	10.0 deg.
Azimuth Angle	0.0 deg.	Gain	6.13 dBi
Outer Ring	6.13 dBi		0.0 dBmax
			0.0 dBmax3D
3D Max Gain	6.13 dBi		
Slice Max Gain	6.13 dBi @ Elev Angle = 10.0 deg.		
Beamwidth	24.4 deg.; -3dB @ 4.9, 29.3 deg.		
Sidelobe Gain	6.13 dBi @ Elev Angle = 170.0 deg.		
Front/Sidelobe	0.0 dB		

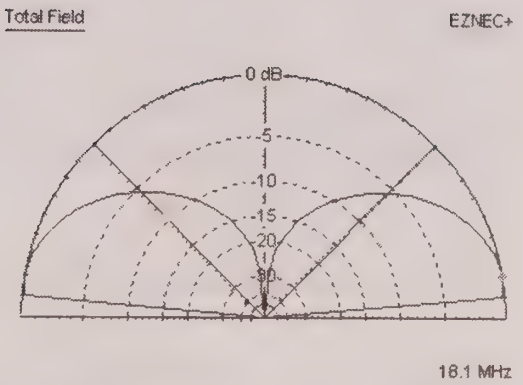
Far field plot for 15m antenna on the beach

17m



Elevation Plot		Cursor Elev	20.0 deg.
Azimuth Angle	0.0 deg.	Gain	0.33 dBi
Outer Ring	0.33 dBi		0.0 dBmax
			0.0 dBmax3D
3D Max Gain	0.33 dBi		
Slice Max Gain	0.33 dBi @ Elev Angle = 20.0 deg.		
Beamwidth	35.2 deg.; -3dB @ 8.7, 43.9 deg.		
Sidelobe Gain	0.33 dBi @ Elev Angle = 160.0 deg.		
Front/Sidelobe	0.0 dB		

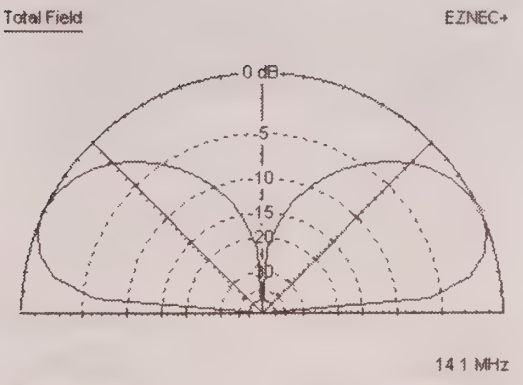
Far field plot for 17m antenna over average ground



Elevation Plot		Cursor Elev	10.0 deg.
Azimuth Angle	0.0 deg.	Gain	5.58 dBi
Outer Ring	5.58 dBi		0.0 dBmax
			0.0 dBmax3D
3D Max Gain	5.58 dBi		
Slice Max Gain	5.58 dBi @ Elev Angle = 10.0 deg.		
Beamwidth	29.8 deg.; -3dB @ 4.9, 34.7 deg.		
Sidelobe Gain	5.58 dBi @ Elev Angle = 170.0 deg.		
Front/Sidelobe	0.0 dB		

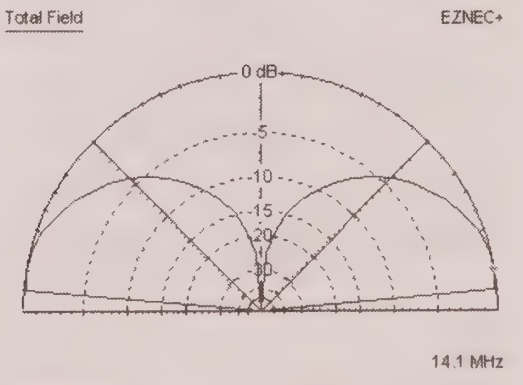
Far field plot for 17m antenna on the beach

20m



Elevation Plot		Cursor Elev	25.0deg.
Azimuth Angle	0.0 deg	Gain	-0.02 dBi
Outer Ring	-0.02 dBi		0.0 dBmax
			0.0 dBmax3D
3D Max Gain	-0.02 dBi		
Slice Max Gain	-0.02 dBi @ Elev Angle = 25.0 deg.		
Beamwidth	39.1 deg.; -3dB @ 9.2, 48.3 deg.		
Sidelobe Gain	-0.02 dBi @ Elev Angle = 155.0 deg.		
Front/Sidelobe	0.0 dB		

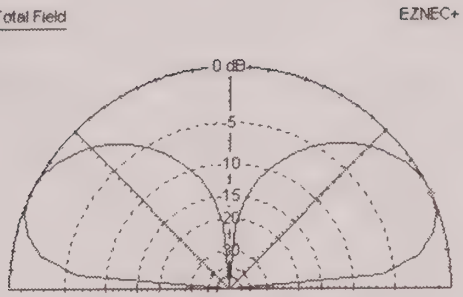
Far field plot for 20m antenna over average ground



Elevation Plot		Cursor Elev	10.0 deg.
Azimuth Angle	0.0 deg	Gain	5.12 dBi
Outer Ring	5.12 dBi		0.0 dBmax
			0.0 dBmax3D
3D Max Gain	5.12 dBi		
Slice Max Gain	5.12 dBi @ Elev Angle = 10.0 deg.		
Beamwidth	33.7 deg.; -3dB @ 4.9, 38.6 deg		
Sidelobe Gain	5.12 dBi @ Elev Angle = 170.0 deg.		
Front/Sidelobe	0.0 dB		

Far field plot for 20m antenna on the beach

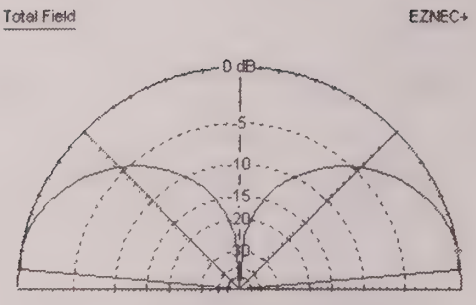
30m



10.1 MHz

Elevation Plot		Cursor Elev	25.0 deg.
Azimuth Angle	0.0 deg.	Gain	-0.18 dBi
Outer Ring	-0.18 dBi		0.0 dBmax
			0.0 dBmax3D
3D Max Gain	-0.18 dBi		
Slice Max Gain	-0.18 dBi @ Elev Angle = 25.0 deg.		
Beamwidth	41.5 deg., -3dB @ 9.3, 50.8 deg		
Sidelobe Gain	-0.18 dBi @ Elev Angle = 155.0 deg.		
Front/Sidelobe	0.0 dB		

Far field plot for 30m antenna over average ground

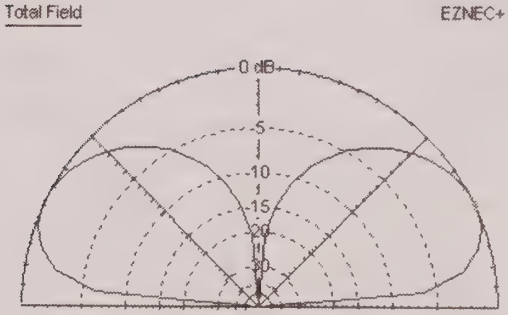


10.1 MHz

Elevation Plot		Cursor Elev	10.0 deg.
Azimuth Angle	0.0 deg	Gain	4.98 dBi
Outer Ring	4.98 dBi		0.0 dBmax
			0.0 dBmax3D
3D Max Gain	4.98 dBi		
Slice Max Gain	4.98 dBi @ Elev Angle = 10.0 deg.		
Beamwidth	33.0 deg., -3dB @ 4.9, 37.9 deg		
Sidelobe Gain	4.98 dBi @ Elev Angle = 170.0 deg.		
Front/Sidelobe	0.0 dB		

Far field plot for 30m antenna on the beach

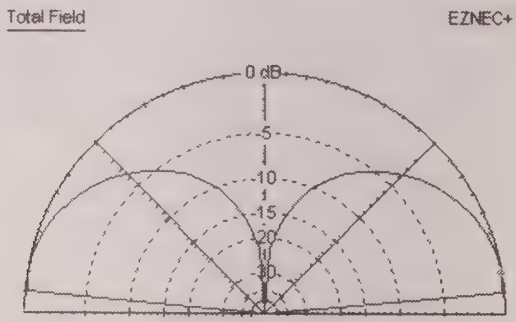
40m



7.1 MHz

Elevation Plot		Cursor Elev	25.0 deg.
Azimuth Angle	0.0 deg.	Gain	-0.26 dBi
Outer Ring	-0.26 dBi		0.0 dBmax
			0.0 dBmax3D
3D Max Gain	-0.26 dBi		
Slice Max Gain	-0.26 dBi @ Elev Angle = 25.0 deg.		
Beamwidth	43.1 deg., -3dB @ 9.3, 52.4 deg.		
Sidelobe Gain	-0.26 dBi @ Elev Angle = 155.0 deg.		
Front/Sidelobe	0.0 dB		

Far field plot for 40m antenna over average ground



7.1 MHz

Elevation Plot		Cursor Elev	10.0 deg.
Azimuth Angle	0.0 deg.	Gain	4.93 dBi
Outer Ring	4.93 dBi		0.0 dBmax
			0.0 dBmax3D
3D Max Gain	4.93 dBi		
Slice Max Gain	4.93 dBi @ Elev Angle = 10.0 deg.		
Beamwidth	37.2 deg., -3dB @ 4.9, 42.1 deg.		
Sidelobe Gain	4.93 dBi @ Elev Angle = 170.0 deg.		
Front/Sidelobe	0.0 dB		

Far field plot for 40m antenna on the beach

8 The *Buddistick*

The *Buddistick* is the smallest member of the *Buddipole* family but it provides great options for quick HF antenna deployments. The major components of a *Buddistick* are

- Two 11 inch accessory antenna arms
- One coil with two coil clips for tapping it
- A 5.5 foot whip
- Mounting plate with knob threaded ¼"x20
- One 31' radial wire on a winder

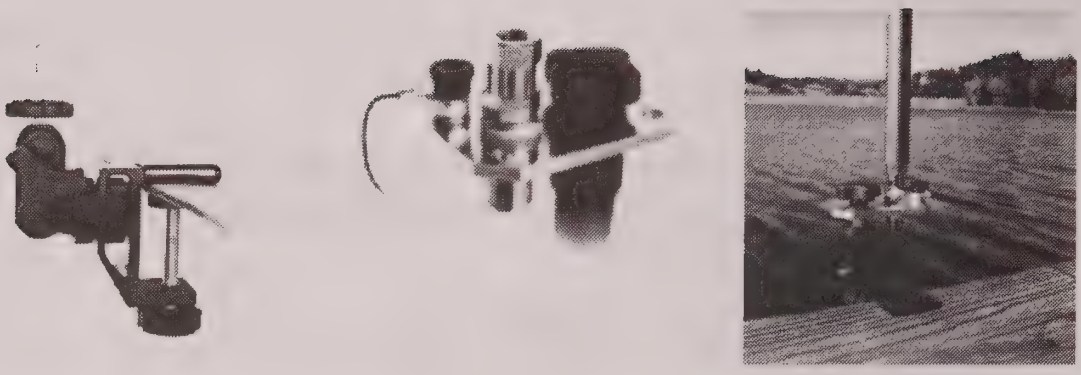
The *Buddistick Deluxe* package includes all the above and

- An antenna clamp
- Additional (spare) 5.5 foot whip
- Additional coil clip

Budd Drummond (W3FF) assembling a *Buddistick* on VP2M

The *Buddistick* is an antenna system designed to create shortened HF vertical antennas from small, portable components. For those familiar with the *Buddipole* the following comparison might be helpful. The *Buddistick* can be considered half a *Buddipole* minus the VersaTee. Instead of two 22 inch antenna accessory arm lengths included in a *Buddipole*, the *Buddistick* has only one 22 inch length (from two 11 inch pieces). Instead of two coils (one black, one red) like those bundled with the *Buddipole* kit, the *Buddistick* has only one coil. Instead of a VersaTee for mounting and feeding the antenna as with the *Buddipole*, the *Buddistick* has only a mounting plate.

The most common deployment for a *Buddistick* is that of a shortened vertical antenna with one or more radials. It is typically mounted on a solid horizontal surface or railing using either a tripod (such as a photographic tripod) or clamp. The *Buddipole Vertical Antenna Clamp* is an optional accessory that provides an easy way to mount the *Buddistick* (on its mounting plate) to a table or deck. The clamp is not especially strong, but a typical deployment is temporary and the clamp is more than adequate for that light duty. Figure 43 shows these items.



Clamp Mounting plate Typical deployment

Figure 43 *Buddistick* standard mounting hardware

The mounting plate is affixed to a clamp or tripod by the small rubber knob as shown in Figure 43. The radial wire attaches to a post on the mounting plate and the feed line is connected to an SO-239 connector on the bottom of the plate.

It is possible to deploy the *Buddistick* system as a *Pedestrian Mobile* antenna from a backpack, walking stick, or other frame. *HFpack* (http://www.hfpack.org) is an HF portable and pedestrian mobile enthusiasts group with over 7000 members specializing in portable, and especially pedestrian mobile, communications. The *Buddistick* is ideal for the creation of pedestrian mobile antenna systems. The vertical element is constructed and the coil is tapped. The radial of the antenna is a single wire dragging behind the walker. A radio, battery, backpack, and *Buddistick* can yield surprising results!

Budd Drummond (W3FF) with a *Buddistick* mounted on bicycle for "bicycle mobile".

Mike Greenwood (KC4VG) pedestrian mobile on VP2M

The alternative to using the standard mounting plate with the clamp or tripod is to use a third-party mount such as the High

High Sierra JAWS mount

Sierra JAWS mount. This mount has a stud with standard $^3/_8$" x 24 threads that accepts *Buddistick* elements. A small hole (shown to the right of the stud) can be used to affix the radial wire. The metal piece holding the stud can rotate 90 degrees to allow the antenna to be parallel to, or perpendicular to, the surface gripped by the jaws. Alternatively, if the radio is close to the antenna (as with a QRP operation on a picnic table) the radial can be connected to the radio frame.

It is always recommended to tie a "safety line" to a *Buddistick* when deploying the antenna off of a balcony or other high place to ensure that a dropped *Buddistick* will not fall striking, injuring, or killing someone below your deployment.

This chapter discusses configuration options for the *Buddistick* and limits the designs to only *Buddistick* components. Add just a few additional components from the *Buddipole accessory store* to generate many more configuration opportunities. Review the *Ground Mounted Verticals* chapter in this book to see how these additional components can be used to create larger and more efficient antennas. For example, the addition of a VersaTee, portable coax assembly, mast, two accessory arms, and a second coil transforms a *Buddistick* into a *Buddipole* enabling you to create any *Buddipole* configuration described.

Buddistick Cookbook

All *Buddistick* antennas in this book have identical assembly configurations. The vertical element is constructed by joining the two 11 inch antenna accessories arms (making a single 22 inch length, as shown in the diagrams), joining the coil to the arms by screwing the post of the coil into the female tap of the arms, and screwing the 5.5 foot whip into the female tap of the coil. The only changes in the configurations described are the tap selected on the coil, and the length of the radial wire.

The tuning guides below provide a good starting point for coil tap selection. However, there may be an easier way to tune the antenna in the field. With the *Buddistick* and radial wire deployed, and the radio tuned to the desired frequency, grasp the wander lead as shown in Figure 44 and slowly drag the banana plug across the coil while listening carefully to the sound from the radio. There should be a spot on the coil where the audio from the radio rises considerably. This point on the coil is the one you want—the one with delivering the most power on receive will also serve you well on transmit.

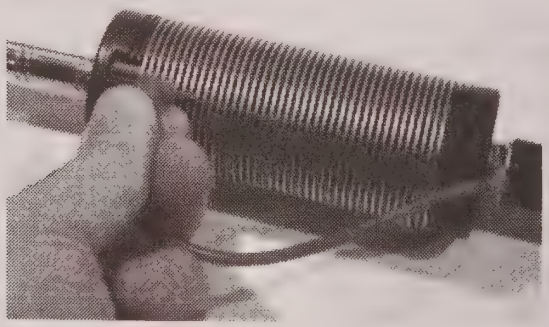


Figure 44 Quick tuning the *Buddistick*

After the desired coil tap has been located, insert the coil clip on that turn and secure the wander lead. The remainder of this chapter provides instructions for creating antennas for each of the supported HF bands.

10m Buddistick

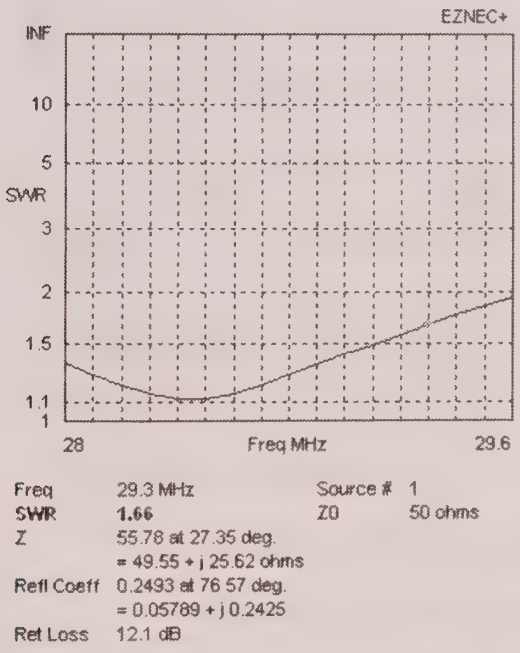
The *Buddistick* is used to create shortened vertical antennas. A full-sized vertical with a good ground system presents about 35 ohms of radiation resistance at the feedpoint. Shorter antennas have less radiation resistance, very short antennas have significantly less radiation resistance. This antenna should present about 26 ohms of radiation resistance but the feedpoint impedance is well over 50 ohms because of losses associated with our poor ground. (Adding radials can reduce ground losses.)

Standard *Buddistick*

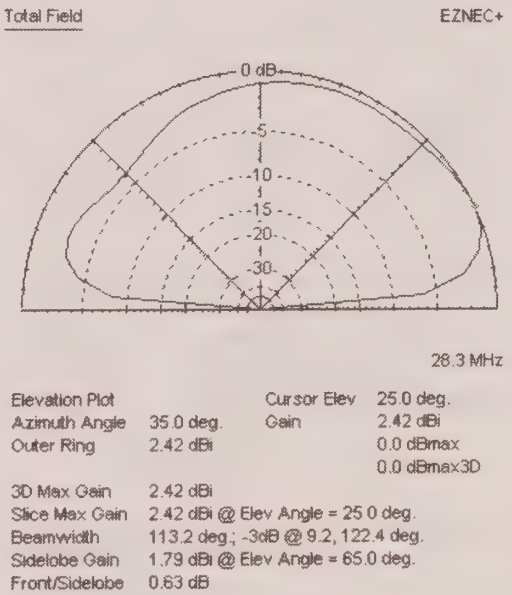
Vertical element
Two 11" antenna accessory arm
Coil: tap 1 or 2
5.5' whip: 6 sections (all out)

Radial
Wire: 7.9 feet (95 inches)

A properly tuned system will provide a good 2:1 SWR bandwidth across the entire 10m band. The performance plots for this band are shown below.



10m *Buddistick* SWR



10m *Buddistick* far field plot

Figure 45 SWR and far field plot for a 10m *Buddistick*

12m Buddistick

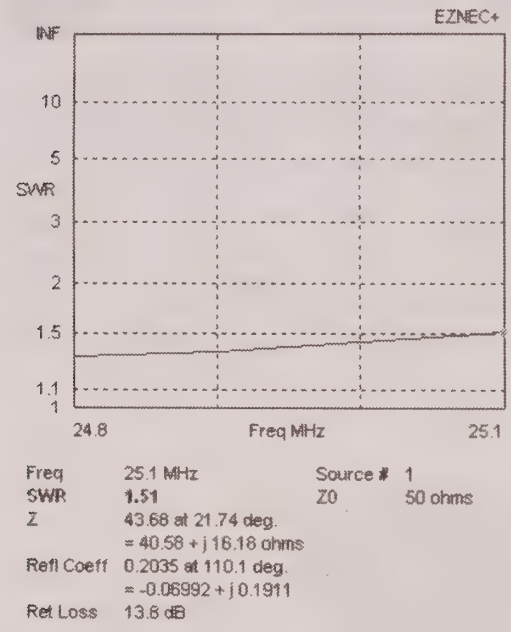
The *Buddistick* should present about 20 ohms of radiation resistance for this band. The feedpoint impedance will likely be near 50 ohms (indicating 30 ohms of loss, mostly through the ground).

Standard ***Buddistick***

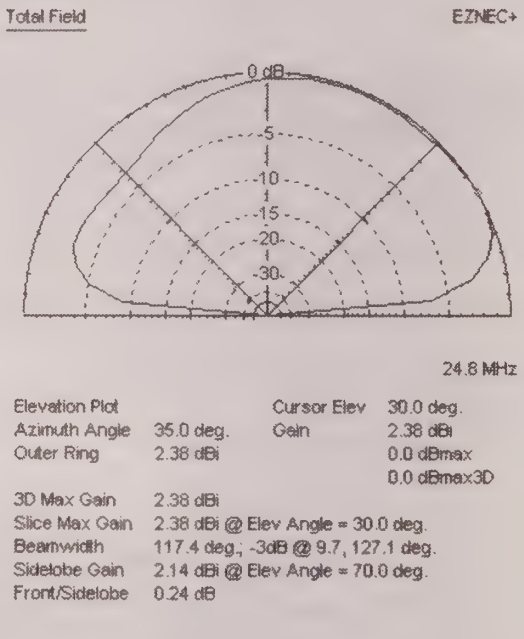
Vertical element
Two 11" antenna accessory arm
Coil: tap 4
5.5' whip: 6 sections (all out)

Radial
Wire: 9.5 feet (113 inches)

A properly tuned system will provide a good 2:1 SWR bandwidth across the entire 12m band. The performance plots for this band are shown below.



12m *Buddistick* SWR



12m *Buddistick* far field plot

Figure 46 SWR and far field plot for a 12m *Buddistick*

15m Buddistick

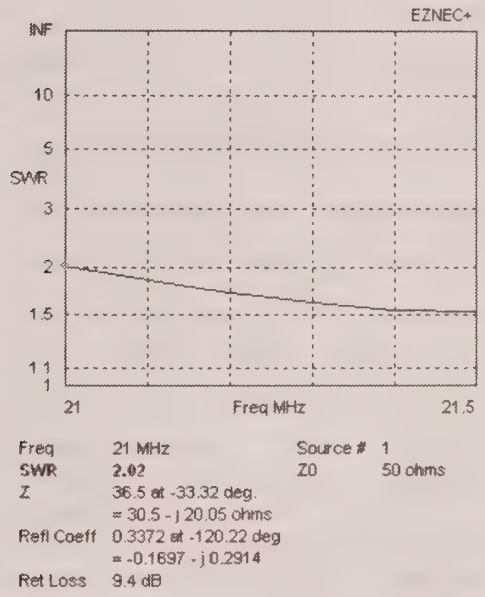
The *Buddistick* should present about 14 ohms of radiation resistance for this band. The feedpoint impedance will be a bit low (near 30 ohms) with that additional impedance a result of losses (mostly ground losses). The antenna can be further tuned to resonance by extending or retracting the length of the radial wire.

Standard *Buddistick*

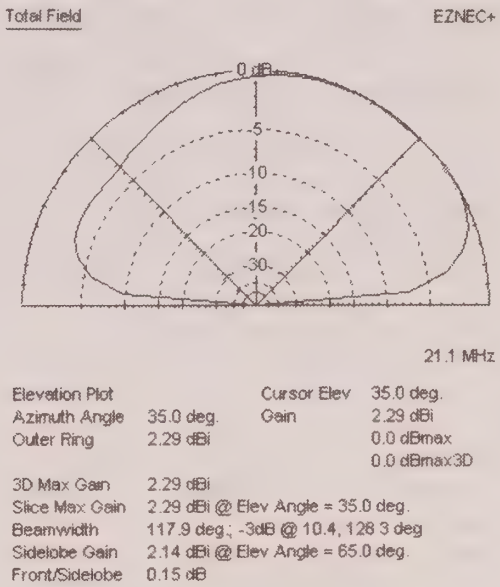
Vertical element
Two 11" antenna accessory arm
Coil: tap 6
5.5' whip: 6 sections (all out)

Radial
Wire: 11 feet (132 inches)

A properly tuned system will provide a good 2:1 SWR bandwidth across the entire 15m band. The performance plots for this band are shown below.



15m *Buddistick* SWR



15m *Buddistick* far field plot

Figure 47 SWR and far field plot for a 15m *Buddistick*

17m Buddistick

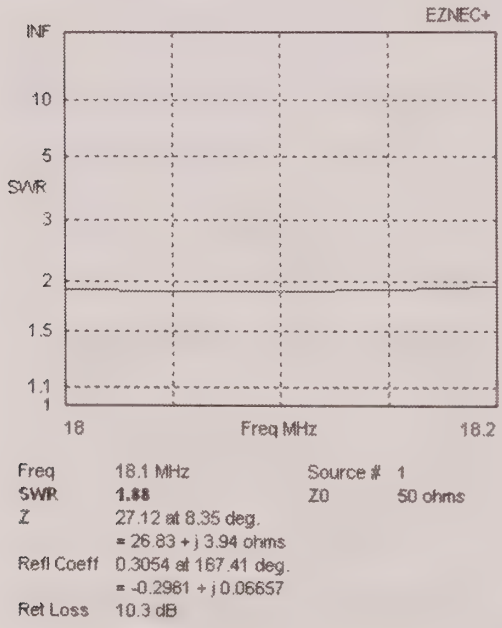
The *Buddistick* should present about 10 ohms of radiation resistance for this band. The total feedpoint impedance will be near 25 ohms. The additional impedance is due to losses, mostly ground losses. The antenna can be further tuned to resonance by extending or retracting the length of the radial wire.

Standard *Buddistick*

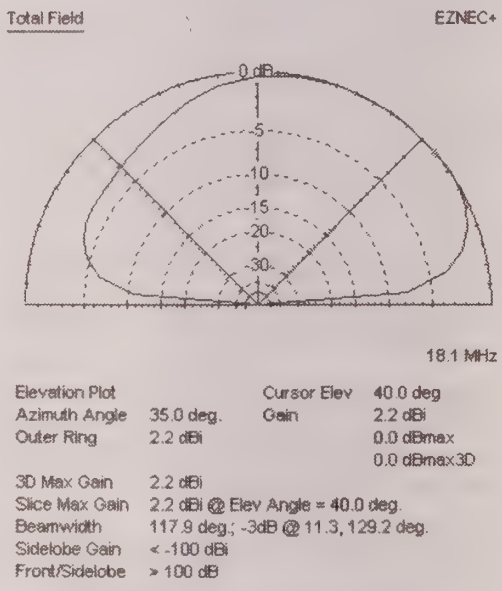
Vertical element
Two 11" antenna accessory arm
Coil: tap 9
5.5' whip: 6 sections (all out)

Radial
Wire: 13 feet (156 inches)

A properly tuned system will provide 2:1 SWR bandwidth across the entire 17m band. (The optional *Triple Ratio Switch Balun* with a 2:1 setting would match this antenna very well to a radio.) The performance plots for this band are shown below.



17m *Buddistick* **SWR**



17m *Buddistick* **far field plot**

Figure 48 SWR and far field plot for a 17m *Buddistick*

20m Buddistick

The *Buddistick* should present about 6 ohms of radiation resistance for this band. A full-sized radiator for the 20m band would be over 16 feet in length. The radiator on the *Buddistick* is only about 7 feet—very short for a vertical for this band. Shorter antennas are more difficult to match, have smaller 2:1 SWR bandwidths, are less efficient than larger alternatives.

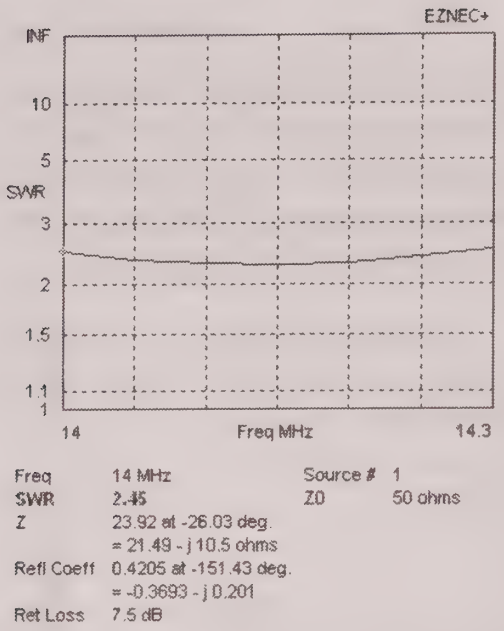
Standard *Buddistick*

Vertical element
- Two 11" antenna accessory arm
- Coil: tap 14
- 5.5' whip: 6 sections (all out)

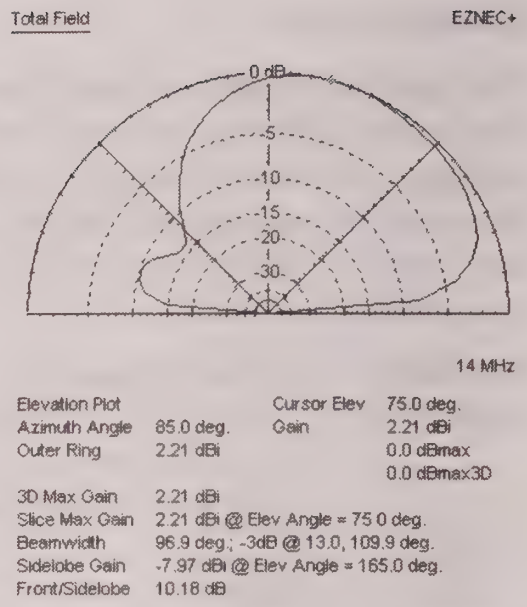
Radial
- Wire: 17.5 feet (210 inches)

The plots in Figure 49 show two of the problems with deploying an antenna this short. The first problem is evidenced in the SWR curve. The extremely low radiation resistance means that the feedpoint impedance at resonance will also be very low. Even with ground losses the low feedpoint impedance still gives an SWR greater than 2:1. (A *Triple Ratio Switch Balun* setting of 2:1 or 4:1 matches this nicely, however.)

The second problem is the relative deafness in the direction opposite the run of the radial. Gain is down over 2 S-units from the front direction.



20m *Buddistick* SWR



20m *Buddistick* far field plot

Figure 49 SWR and far field plot for a 20m *Buddistick*

30m and 40m Buddistick

The *Buddistick* components in the standard kit cannot create effective antennas for 30m or 40m. If one attempts to create an antenna for these bands a horizontal dipole is created from the very long radial and shortened vertical element as illustrated in Figure 50. The off-center fed antenna consists of one long wire leg and a severely shortened second leg made from the arm, coil, and whip.

Figure 50 Attempted antenna design for 40m *Buddistick* vertical

The chapter on *Ground mounted* antennas discusses vertical antenna configurations for these bands. It is possible with a sufficiently sized vertical radiator to create effective vertical antennas but a single 22 inch antenna accessory arm length and short whip do not provide enough of a radiator to support these bands.

9 *Buddipole* beams

Accessory antenna arms, those 22 inch (or 11 inch) pieces of aluminum used in antenna elements in single element antennas can also be used as boom components in Yagis. This chapter shows how to build multi-element antennas from basic *Buddipole* kits and *Buddipole* accessories.

Buddipole Yagi Antenna Cookbook

6m two element Yagi

Buddipole, Inc. sells a *6m Yagi Kit* that includes all the extra pieces you need to construct a 2 element 6m Yagi from a *Buddipole Deluxe* kit. (A total of four standard whips are also required.) The general idea is to use the two 22 inch arms for the boom of the antenna. An IT adapter is used to link together the arms. Another IT adapter is used to hold the whips for the reflector element. The Yagi collar is used to prevent the rotation of items affixed to the end of the boom.

The boom is affixed to the top of the mast by a special adapter included in the kit and is secured by a bolt and knob from the Rotating Arm Kit. A second bolt and knob is used to attach the reflector to the boom.

The parts list for this antenna appears below:

1	Standard (5.5 foot) whip x 4
2	*Buddipole* 22 inch arm x 2
3	*Buddipole* VersaTee x 1
4	IT adapter x 2
5	Yagi collar x 2
6	Mast adapter x 1
7	*Buddipole* 8 foot mast x 1
8	*Buddipole* tripod x 1
9	3/8 inch x 24 x 1+1/8 long threaded adapter x 1

Table 9 *Buddipole* 6m two element Yagi parts list

Figure 51 *Buddipole* 6m two element Yagi below illustrates the assembled antenna. Note the placement of the VersaTee, IT adapters, and the two bolts and knobs. (The diagram is not to scale.)

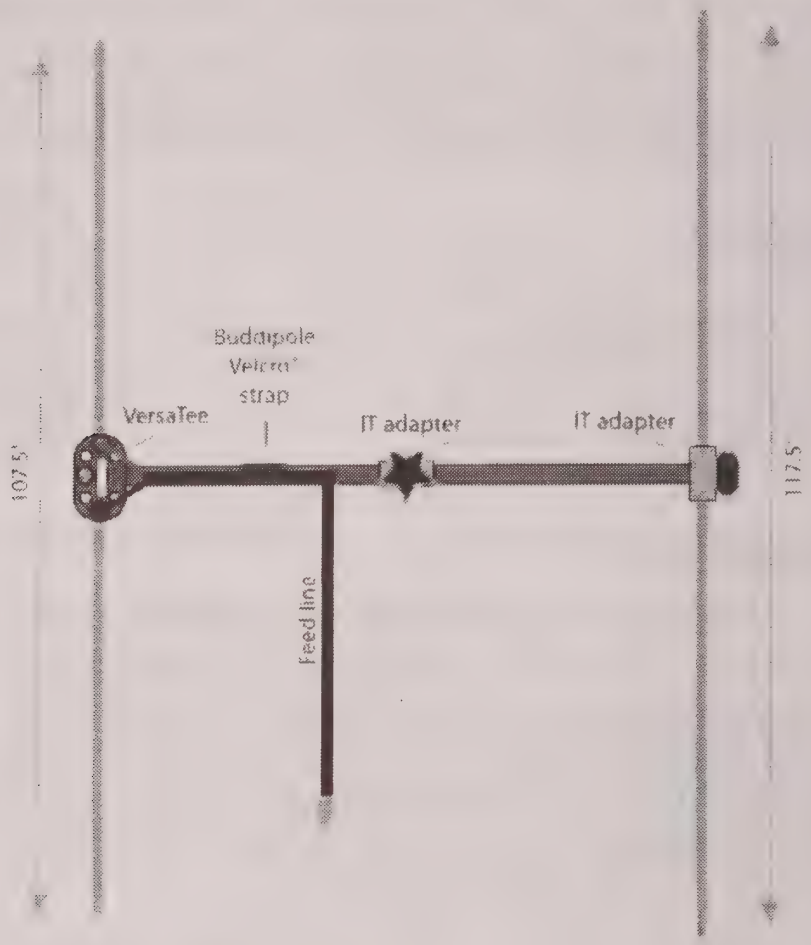


Figure 51 *Buddipole* 6m two element Yagi

A computer model in EZNEC+ shows significant gain over a simple 6m dipole. The figures below contain the EZNEC+ view of the antenna.

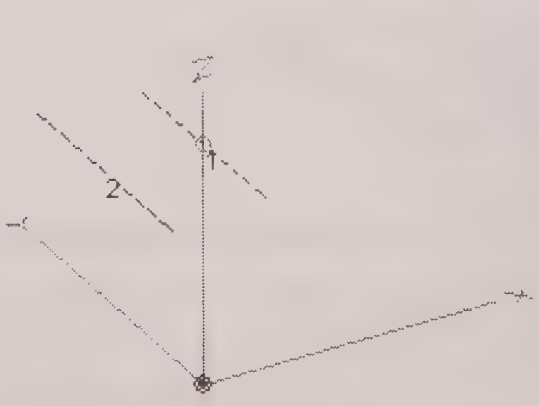


Figure 52 *Buddipole* 6m two element Yagi EZNEC+ plot

The antenna is constructed from the parts listed in Table 9 as per the diagram in Figure 53 below. (The diagram is not to scale.)

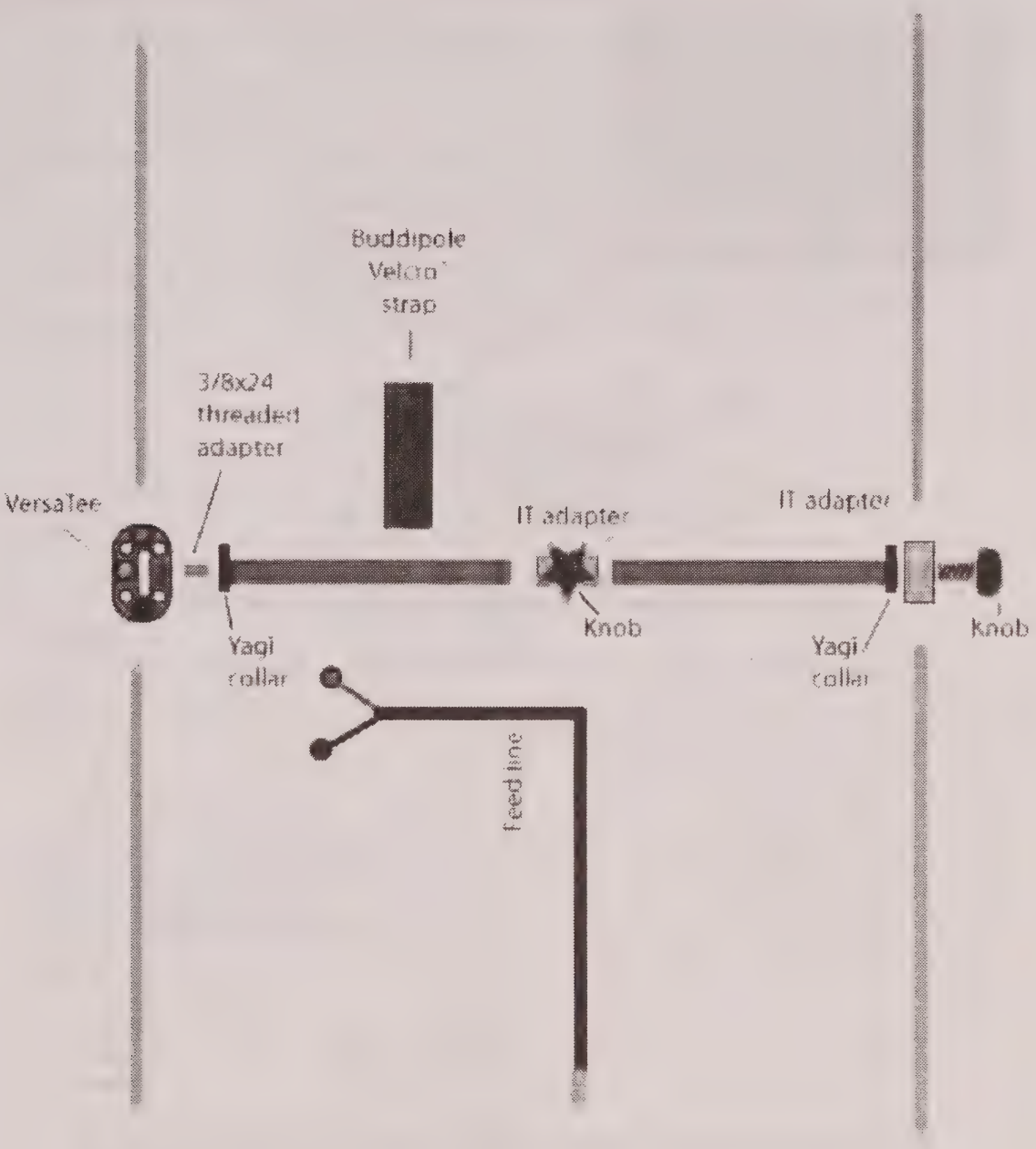
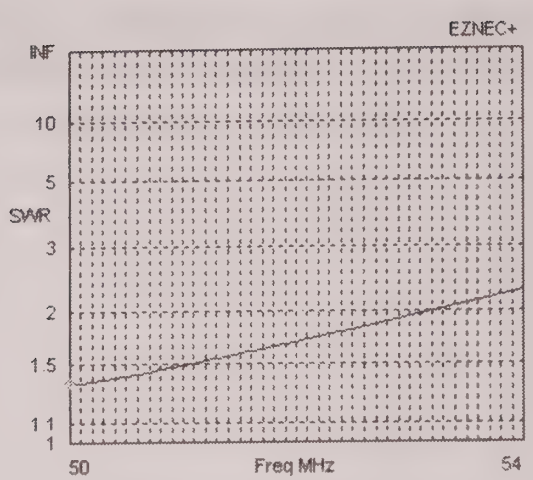


Figure 53 Building the two element Yagi from the *Buddipole* Yagi kit

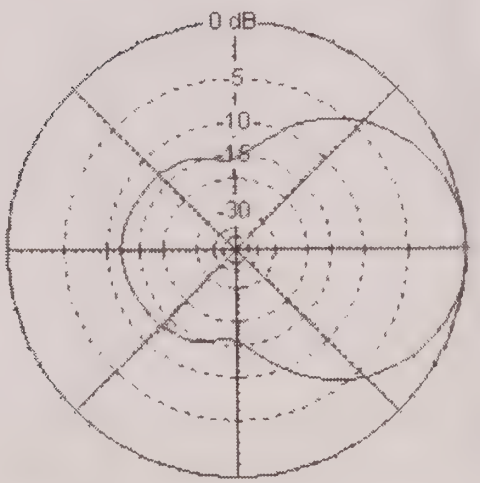
All two element Yagis in this chapter are built from this diagram—with the exception of antennas demanding four arms instead of the two shown above.

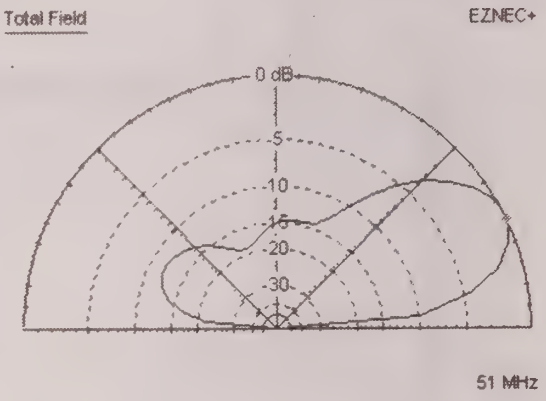
The SWR and far field plots (both azimuth and elevation) are shown in Figure 54 and Figure 55.



Freq	50 MHz	Source #	1
SWR	1.35	Z0	50 ohms
Z	66.46 at -5.88 deg.		
	= 66.11 - j 6.803 ohms		
Refl Coeff	0.1504 at -19.54 deg.		
	= 0.1417 - j 0.05029		
Ret Loss	16.5 dB		

Figure 54 SWR plot for *Buddipole* 6m two element Yagi





Elevation Plot		Cursor Elev	25.0 deg.
Azimuth Angle	0.0 deg.	Gain	10.46 dBi
Outer Ring	10.46 dBi		0.0 dBmax
			0.0 dBmax3D

3D Max Gain	10.46 dBi
Slice Max Gain	10.46 dBi @ Elev Angle = 25.0 deg.
Beamwidth	30.8 deg.; -3dB @ 12.8, 43.6 deg.
Sidelobe Gain	-1.44 dBi @ Elev Angle = 150.0 deg.
Front/Sidelobe	11.9 dB

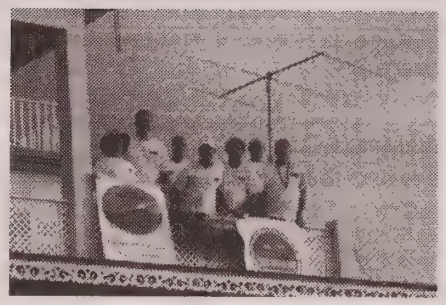
Far field azimuth plot **Far field elevation plot**

Figure 55 Far field plots for *Buddipole* 6m two element Yagi

This antenna provides approximately 10dBi of gain at 25 degrees elevation. It also provides a front-to-back ratio of about 12 dB.

6m three element Yagi

One can construct a three element Yagi with a few extra parts. The author has used this design on several occasions including the DXpedition to Montserrat, and various CQ WW VHF contest efforts atop Mount Wachusetts in Massachusetts. It performs very well. Here is what you need to build this antenna:



6m Yagi on VP2M

1	*Buddipole Deluxe* antenna
2	IT adapters (3)
3	RAK bolt and knobs (3)
4	Standard whips (5.5 foot) (6)
5	22 inch arms (4)

Figure 56 *Buddipole* 6m three element Yagi parts list

Figure 57 shows the antenna configuration. (The diagram is not to scale.)

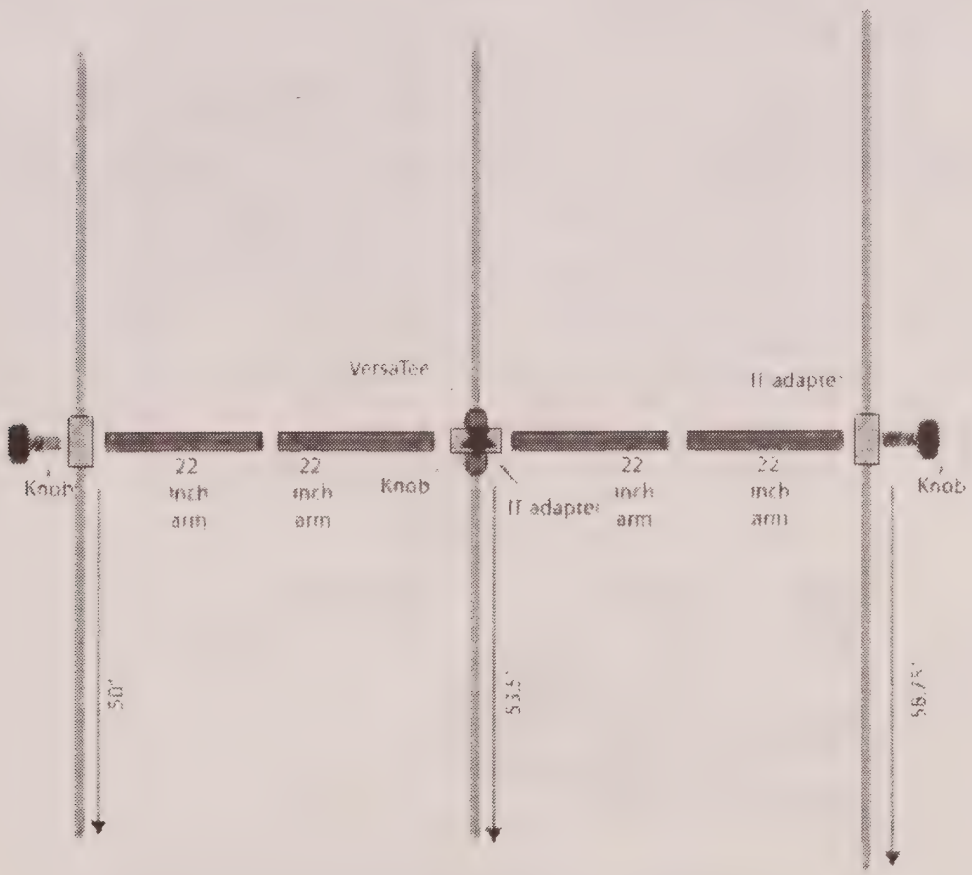


Figure 57 *Buddipole* 6m three element Yagi

The whips connected to the VersaTee are the driven elements (just like a regular dipole configuration). The EZNEC+ view of this antenna and its SWR plot appear below in Figure 58 and Figure 59 respectively.

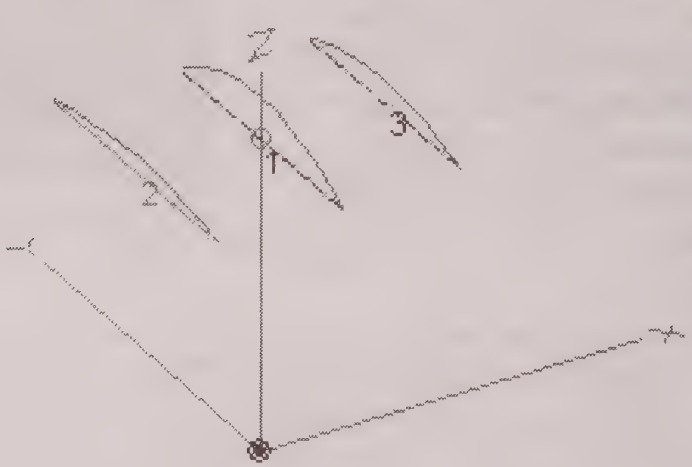
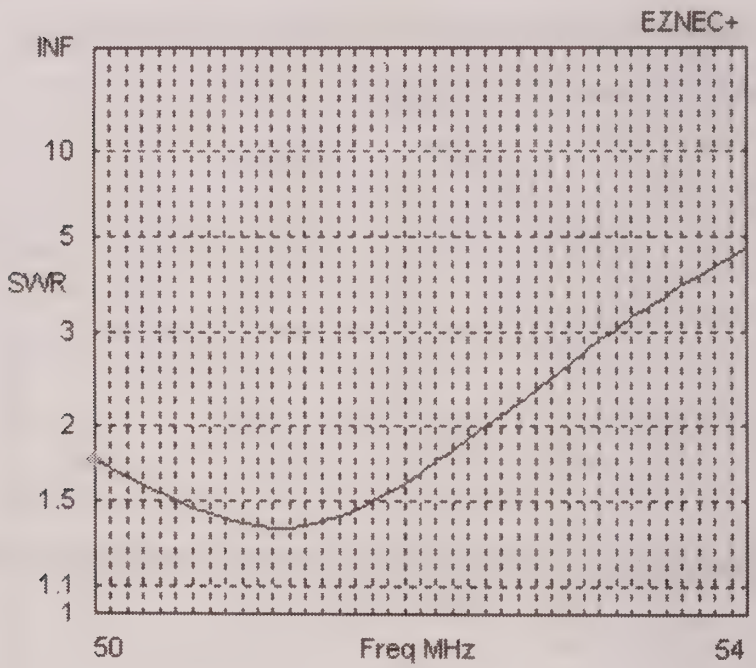


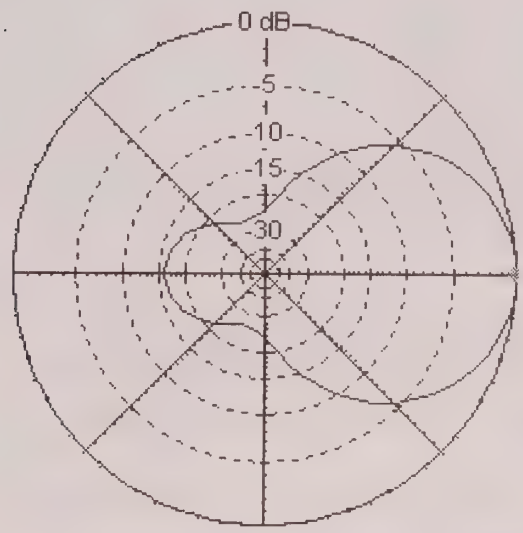
Figure 58 *Buddipole* 6m three element Yagi EZNEC+ plot

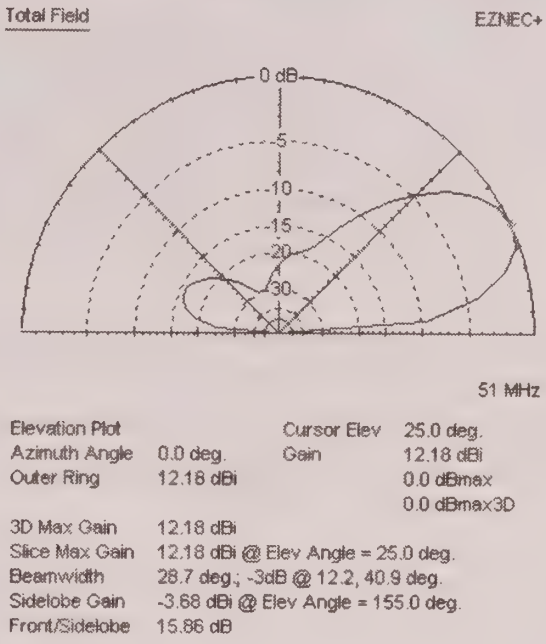


Freq	50 MHz	Source #	1
SWR	**1.74**	Z0	50 ohms
Z	42.52 at -28.96 deg.		
	= 37.2 - j 20.58 ohms		
Refl Coeff	0.2705 at -108.59 deg.		
	= -0.08624 - j 0.2564		
Ret Loss	11.4 dB		

Figure 59 SWR plot for *Buddipole* 6m three element Yagi

The tuning for this antenna is slightly sharper than that of the two element configuration but it delivers slightly higher gains as shown in the far field plots of Figure 60.





Far field azimuth plot Far field elevation plot

Figure 60 Far field and elevation plot for the 6m 3 element yagi

Both the 2 element and 3 element versions of the *Buddipole* 6m Yagi are easy to assemble, relatively compact, and lightweight for the performance they deliver.

2m three element Yagi

A 3 element Yagi for 2m can be created with three *IT adapters*, two full *Rotating Arm Kits*, and six of the standard 5.5 foot whips. The complete parts list is shown below.

1	*Buddipole Deluxe* antenna
2	IT adapters (3)
3	RAK bolt and knobs (3)
4	Standard whips (5.5 foot) (6)
5	22 inch arms (2)

The assembly is similar to the 6m three element Yagi except that only two antenna arms are used instead of four. The two whips connected to the VersaTee are the driven elements (just like a regular dipole). See Figure 61. (The diagram is not to scale.)

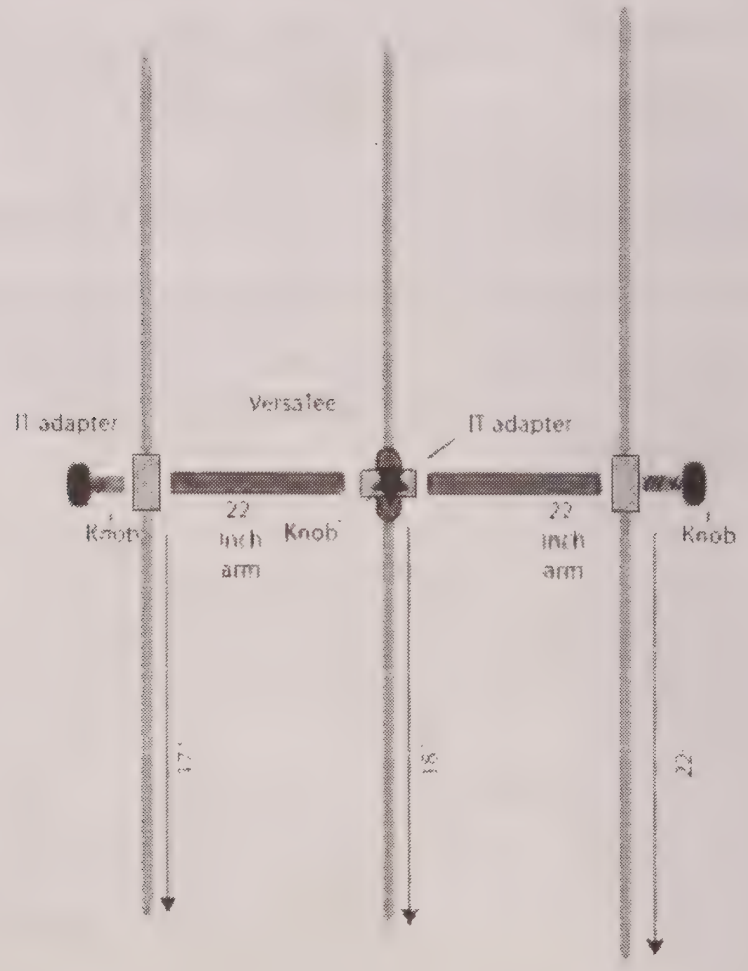
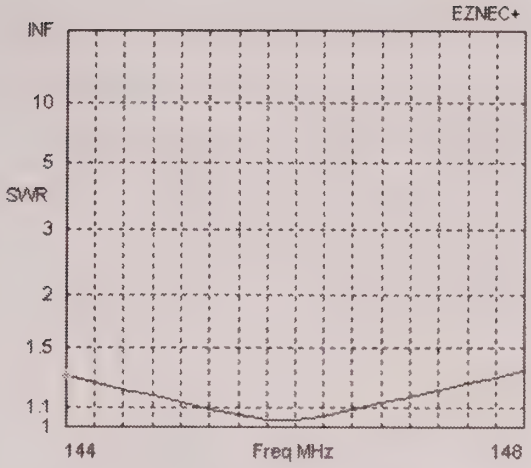
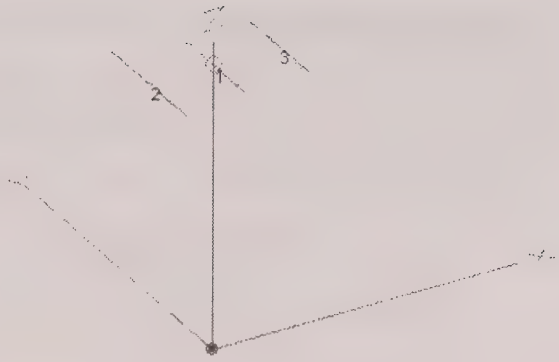


Figure 61 *Buddipole* 2m three element Yagi

This antenna configuration produces a very well matched antenna (with SWR well below 1.5:1 for the entire 2m band) as shown in Figure 62.



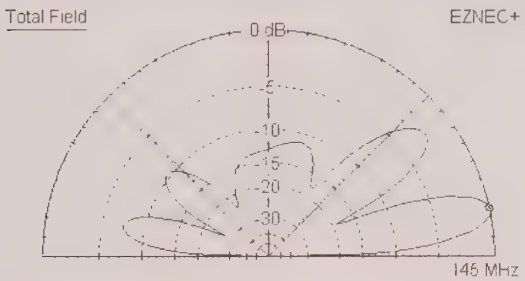
Freq	144 MHz	Source #	1
SWR	1.29	Z0	50 ohms
Z	50.53 at -14.55 deg.		
	= 48.91 - j 12.69 ohms		
Refl Coeff	0.1278 at -87.61 deg.		
	= 0.005326 - j 0.1277		
Ret Loss	17.9 dB		



SWR plot for 2m 3 element Yagi **EZNEC+ view**

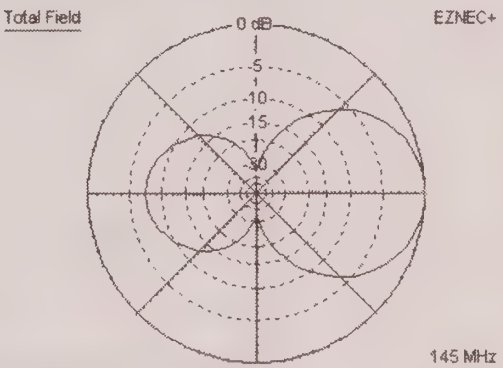
Figure 62 SWR plot and EZNEC+ view of the 2m three element Yagi

This configuration gives 12.44 dBi as shown in the far field plots in Figure 63.



Elevation Plot		Cursor Elev	12.0 deg
Azimuth Angle	0.0 deg.	Gain	12.67 dBi
Outer Ring	12.67 dBi		0.0 dBmax

Slice Max Gain	12.67 dBi @ Elev Angle = 12.0 deg
Beamwidth	12.3 deg., -3dB @ 5.8, 18.1 deg
Sidelobe Gain	10.37 dBi @ Elev Angle = 38.0 deg
Front/Sidelobe	2.3 dB



Azimuth Plot		Cursor Az	0.0 deg.
Elevation Angle	10.0 deg.	Gain	12.44 dBi
Outer Ring	12.44 dBi		0.0 dBmax
			0.0 dBmax3D

3D Max Gain	12.44 dBi
Slice Max Gain	12.44 dBi @ Az Angle = 0.0 deg.
Front/Back	7.26 dB
Beamwidth	64.6 deg.; -3dB @ 327.7, 32.3 deg.
Sidelobe Gain	5.18 dBi @ Az Angle = 180.0 deg.
Front/Sidelobe	7.26 dB

Far field elevation plot **Far field azimuth plot**

Figure 63 Far field plots for the *Buddipole* 2m three element Yagi

If you have an opportunity for "hilltopping" or other VHF work, this *Buddipole* configuration can provide a great antenna solution.

10m 2 element Yagi

The 10m two element Yagi is similar to the 6m Yagi except that the 5.5 foot whips are replaced by 9.5 foot whips, and the boom is constructed from four arms instead of two. The parts are listed in Table 10.

1	9.5 foot whip x 4
2	*Buddipole* 22 inch arm x 4
3	*Buddipole* VersaTee x 1
4	IT adapter x 2
5	Yagi collar x 2
6	Mast adapter x 1
7	*Buddipole* 8 foot mast x 1
8	*Buddipole* tripod x 1
9	3/8 inch x 24 x 1+1/8 long threaded adapter x 1

Table 10 Parts list for 10m two element Yagi

The assembly diagram appears below in Figure 64. (The diagram is not to scale.)

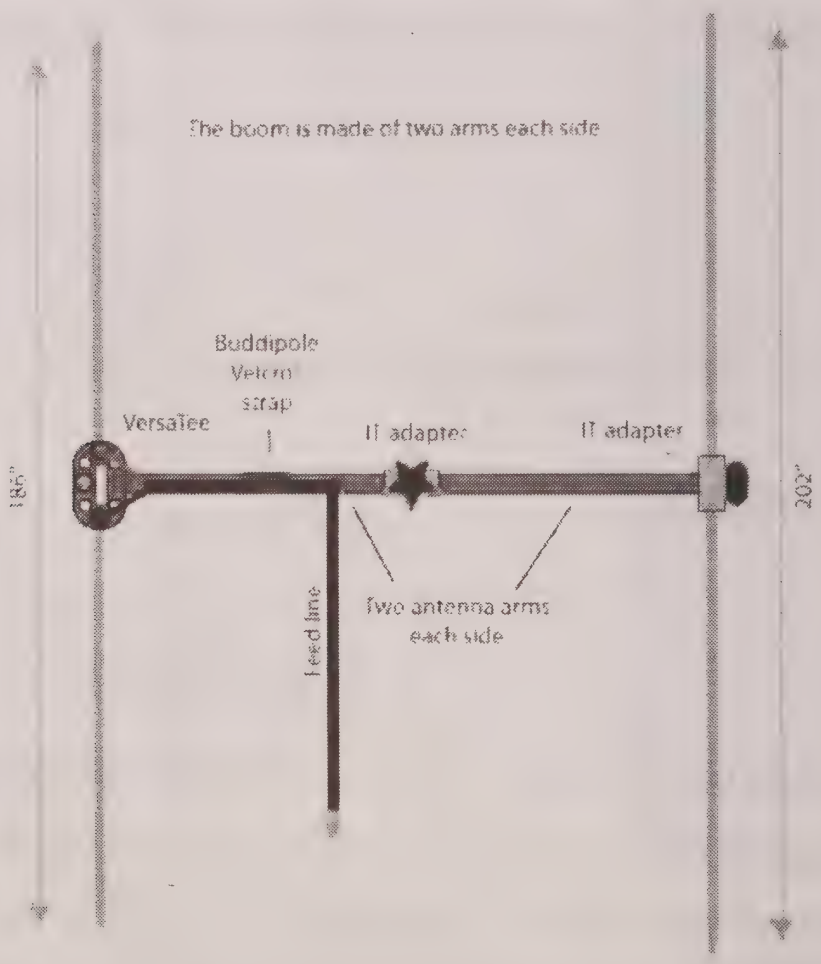
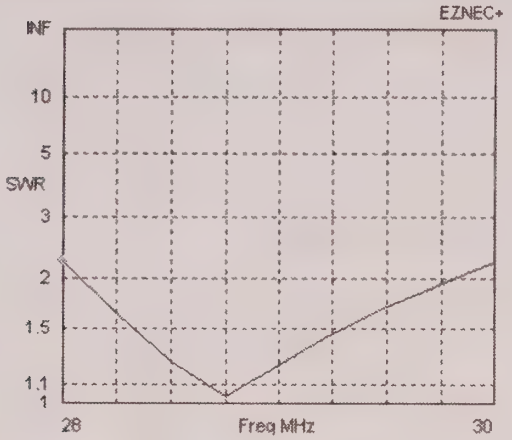
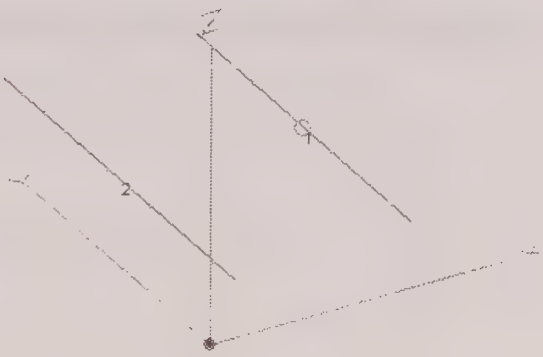


Figure 64 Assembly diagram for *Buddipole* 10m two element Yagi

The SWR plot and EZNEC+ view of this antenna appears below in Figure 65.



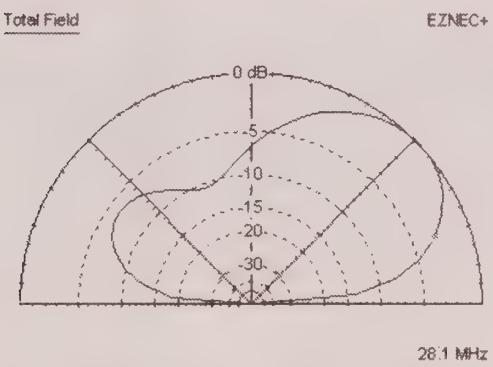
Freq	28 MHz	Source #	1
SWR	2.2	Z0	50 ohms
Z	49.2 at -41.17 deg		
	= 37.03 - j 32.39 ohms		
Refl Coeff	0.3757 at -91.41 deg.		
	= -0.009243 - j 0.3756		
Ret Loss	8.5 dB		



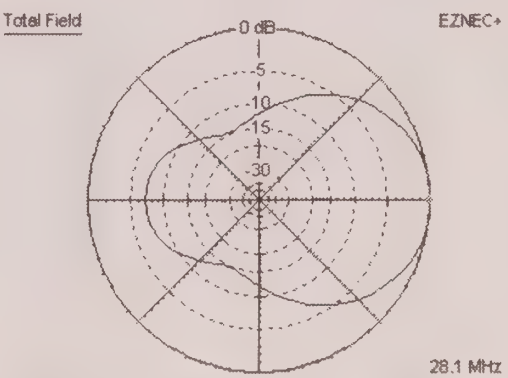
SWR plot for 10m Yagi **EZNEC+ view**

Figure 65 SWR plot and EZNEC+ view of 10m Yagi

The far field plots for this antenna appear below in Figure 66.



Elevation Plot		Cursor Elev	20.0 deg.
Azimuth Angle	0.0 deg.	Gain	5.58 dBi
Outer Ring	8.54 dBi		-2.96 dBmax
			-2.96 dBmax3D
3D Max Gain	8.54 dBi		
Slice Max Gain	8.54 dBi @ Elev Angle = 45.0 deg.		
Beamwidth	54.4 deg.; -3dB @ 19.9, 74.3 deg.		
Sidelobe Gain	2.15 dBi @ Elev Angle = 145.0 deg		
Front/Sidelobe	6.39 dB		



Azimuth Plot		Cursor Az	0.0 deg
Elevation Angle	45.0 deg.	Gain	8.54 dBi
Outer Ring	8.54 dBi		0.0 dBmax
			0.0 dBmax3D
3D Max Gain	8.54 dBi		
Slice Max Gain	8.54 dBi @ Az Angle = 0.0 deg.		
Front/Back	7.02 dB		
Beamwidth	83.4 deg.; -3dB @ 318.3, 41.7 deg.		
Sidelobe Gain	1.52 dBi @ Az Angle = 180.0 deg		
Front/Sidelobe	7.02 dB		

Far field elevation plot **Far field azimuth plot**

Figure 66 Far field plots for *Buddipole* 10m Yagi

The antenna provides a maximum of 8.54 dBi of gain and 5.58 dBi gain at 20 degrees. It is an excellent antenna for its size.

12m 2 element Yagi

The 12m Yagi is identical to the 10m Yagi except for whip lengths. The whip lengths are shown in Figure 67. (The diagram is not to scale.)

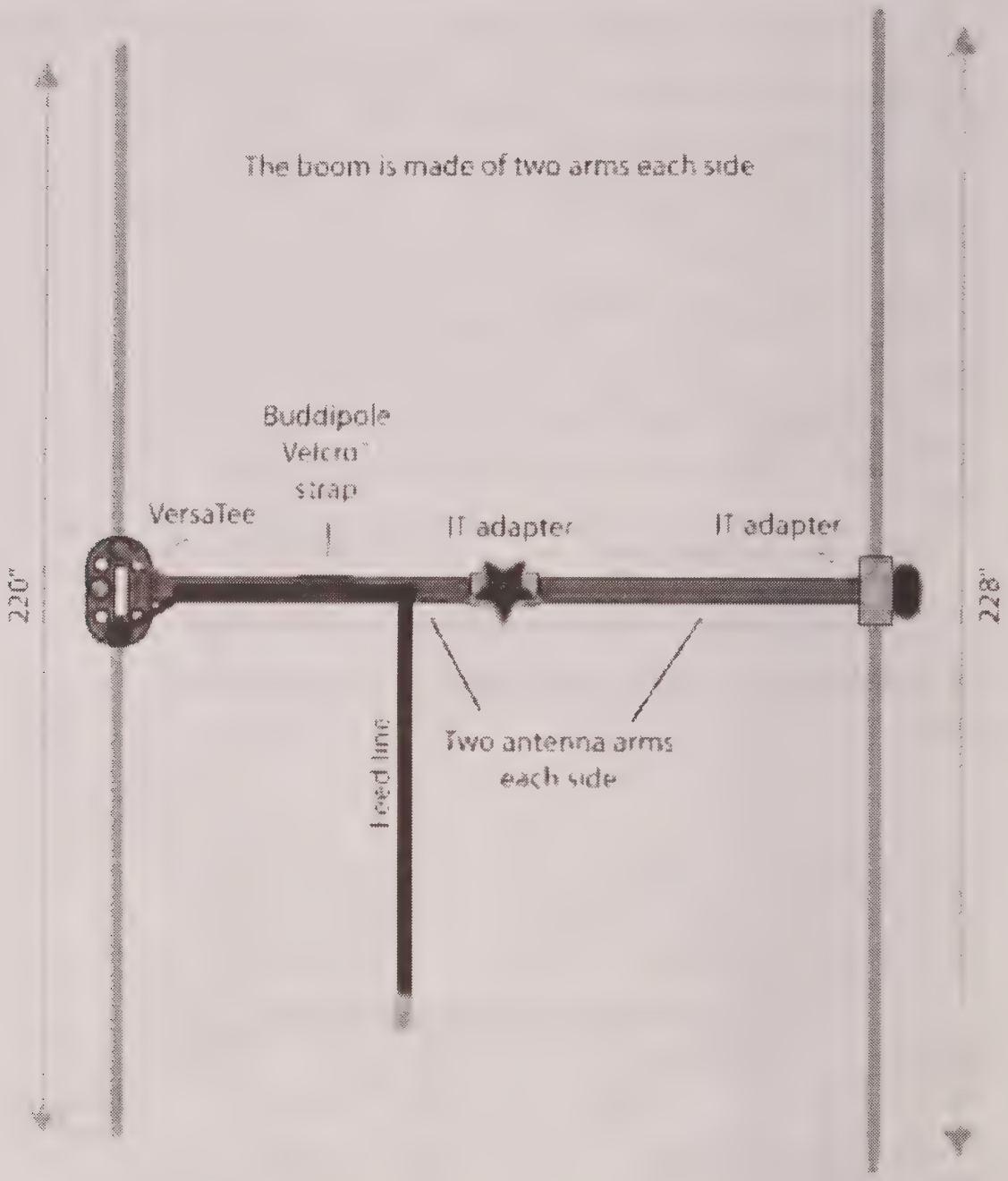
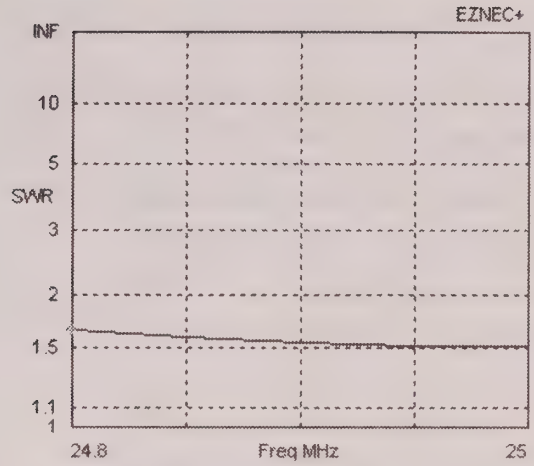


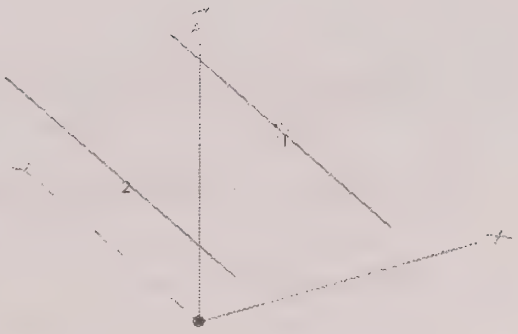
Figure 67 Assembly diagram for the *Buddipole* 12m Yagi

The SWR plot and EZNEC+ view of this antenna is shown in Figure 68. The antenna provides a good match (well under 2:1 SWR) across the small 12m band.



Freq	24.8 MHz	Source #	1
SWR	1.65	Z0	50 ohms
Z	30.85 at -7.22 deg.		
	= 30.6 - j 3.878 ohms		
Refl Coeff	0.2451 at -165.94 deg.		
	= -0.2378 - j 0.05955		
Ret Loss	12.2 dB		

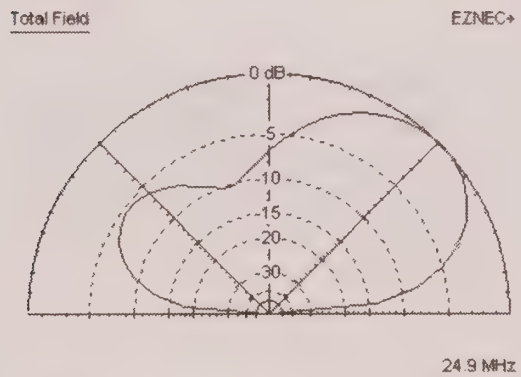
SWR plot for 12m Yagi



EZNEC+ view

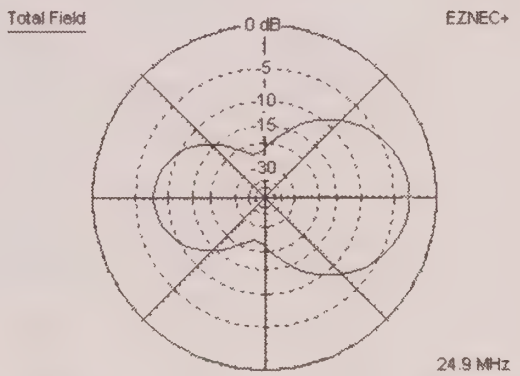
Figure 68 SWR and EZNEC+ view of *Buddipole* 12m Yagi

The antenna provides approximately 5 dBi gain and has a good front-to-back gain ratio.



Elevation Plot		Cursor Elev	20.0 deg.
Azimuth Angle	0.0 deg.	Gain	5.01 dBi
Outer Ring	8.07 dBi		-3.06 dBmax
			-3.06 dBmax3D
3D Max Gain	8.07 dBi		
Slice Max Gain	8.07 dBi @ Elev Angle = 45.0 deg.		
Beamwidth	53.9 deg.; -3dB @ 20.2, 74.1 deg.		
Sidelobe Gain	2.47 dBi @ Elev Angle = 145.0 deg.		
Front/Sidelobe	5.6 dB		

Far field elevation plot



Azimuth Plot		Cursor Az	0.0 deg.
Elevation Angle	20.0 deg.	Gain	5.01 dBi
Outer Ring	8.07 dBi		0.0 dBmax
			-3.06 dBmax3D
3D Max Gain	8.07 dBi		
Slice Max Gain	5.01 dBi @ Az Angle = 0.0 deg		
Front/Back	4.55 dB		
Beamwidth	70.6 deg.; -3dB @ 324.7, 35.3 deg.		
Sidelobe Gain	0.46 dBi @ Az Angle = 180.0 deg.		
Front/Sidelobe	4.55 dB		

Far field azimuth plot

Figure 69 Far field plots for *Buddipole* 12m Yagi

10 Low band antennas

We shall consider the 60m and 80m bands in this chapter. Low band antennas present two challenges at deployment:

- **Matching the very low radiation resistance.** A full-sized vertical antenna will present about 35 ohms of radiation resistance at the feedpoint. As the antenna becomes smaller the radiation resistance shrinks. Table 11 shows the radiation resistance for the likely configuration options for each band. When the radiation resistance is only a couple of ohms, even the *Triple Ratio Switch Balun* set to the 4:1 does not provide a sufficient match for our 50 ohm radios. Unfortunately, the easiest way to create a good match (raise the feedpoint impedance closer to 50 ohms) is to increase losses, thereby reducing antenna efficiency.
- **Reducing ground, coil, and other losses.** Losing a few extra ohms through losses on the high bands (when the radiation resistance is 20-35 ohms) is of small consequence. Losing a few extra ohms when the radiation resistance is only half an ohm (0.5 ohms) reduces antenna efficiency significantly.

Band	Description	Element length (in)	angle	Rrad (ohms)
40m[5]	arms*2+5.5'	110	25	2.5
	arms*2+9.5'	158	35	4.9
	arms*3+9.5'	180	40	6.6
	arms*4+9.5'	202	45	8.3
	arms*4+12'	232	52	10.9
60m	arms*2+5.5'	110	19	1.2
	arms*2+9.5'	158	27	2.5
	arms*3+9.5'	180	31	3.3
	arms*4+9.5'	202	34	4.1
	arms*4+12'	232	39	5.5
80m	arms*2+5.5'	110	12	0.5
	arms*2+9.5'	158	18	1.1
	arms*3+9.5'	180	20	1.5
	arms*4+9.5'	202	23	1.8
	arms*4+12'	232	26	2.4

Table 11 Radiation resistance for bands 40m-80m as a function of length

[5] Data for 40m antennas is only presented for comparisons to the other bands.

Table 11 shows configuration options for each band, the vertical radiator length (in inches) for that option, the *angle* for that length on this band (see APPENDIX E for information on length expressed as an angle), and the radiation resistance. For example, the first line describes an 80m antenna made from two arms (arms*2) and a 5.5 foot whip. The total length of this radiator is 100 inches. That represents a 25 degree angle for the radiator length for this band (90 degrees is a full-sized radiator, a quarter wave, one quarter of 360 degrees). This should present about 2.5 ohms of radiation resistance. The remainder of the table describes other configurations for the 40m, 60m, and 80m bands. The 12 foot whips mentioned in the table are the 7 section shock-cord whips available from the *Buddipole* accessory store.

Antennas for 40m discussed in the *Ground Mounted Verticals* chapter show how difficult it is to create an antenna for a low band that provides reasonable performance. The problems only get worse as the wavelength size increases. Again, as antennas are shortened they present increasing capacitive reactance at the feedpoint. Shortened verticals built from *Buddipole* components for the lower bands are very, very short—presenting very large capacitive reactance components to the feedpoint impedance. A very large inductive reactance must be supplied to cancel this and to bring the antenna into resonance.

The *Buddipole Low Band Coil* can provide this needed inductive reactance. The standard *Buddipole* coil can provide about 22 μH of inductance. The *Low Band Coil* can supply up to 300 μH or so of inductance. Further, the diameter of the *Low Band Coil* is larger than the standard coil so losses from the coil itself are smaller than that of the standard coil for equivalent inductances. (Note that the *Low Band Coil* can be used for higher bands, too.)

The feedpoint impedances, and especially radiation resistance values, presented by a short vertical can be very low. Unfortunately, losses from a poor ground system, losses from coils, and other losses can be much higher than those in high-band antennas. Antenna efficiencies of 1% or lower (much lower) are not only possible, but are common. Assuming a match can be made acceptable to the radio, full output from the radio will result in only a fraction of that power output as useful radiation. Setting a 100 watt radio to full power might result in radiating as little as a watt, or even a fraction of a watt from the antenna. It is easy to be discouraged by these numbers!

Antennas with very low efficiencies for the low bands are common on mobile installations and many mobile operators do very well with such

antennas. Recall the NCDXF beacon system. Some signals from that system are transmitted at less than 1 watt and are easily heard. One must keep some perspective here. These shortened verticals will not perform like a full-sized antenna, but neither will they be a "dummy load" unable to facilitate contacts.

Since we cannot easily make the vertical component longer, the only other way to increase antenna efficiency is to reduce losses. Recall

$$\text{Efficiency\%} = \frac{\text{Radiation_resistance}}{\text{Radiation_resistance} + \textit{Losses}} x100$$

We reduced losses from reactance by adding inductive reactance (the coil) to cancel the capacitive reactance presented by the shortened antenna. If the antenna can be brought into resonance the reactance portion in the *Losses* will become zero. This leaves the ohmic resistance, resulting mostly from ground losses. Can we reduce this ground loss? Yes. Supplying 16 radials, 0.1 wavelength in length, produces an antenna configuration like the one in Figure 70.

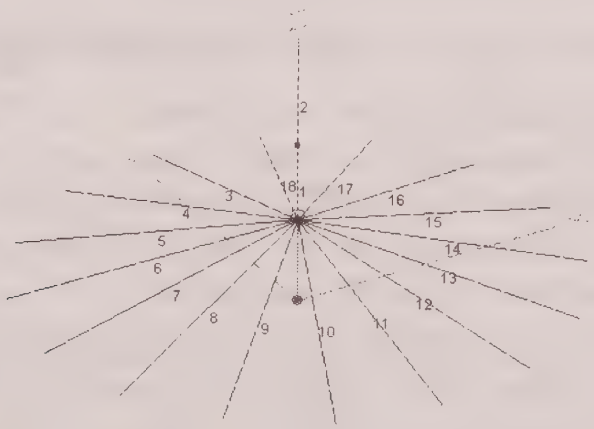
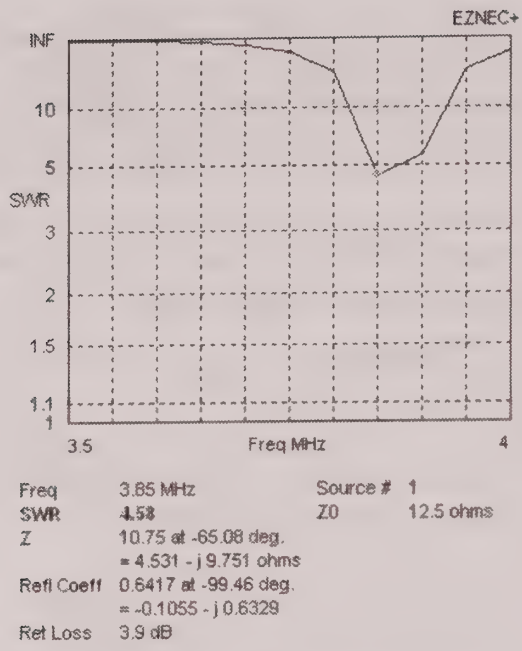
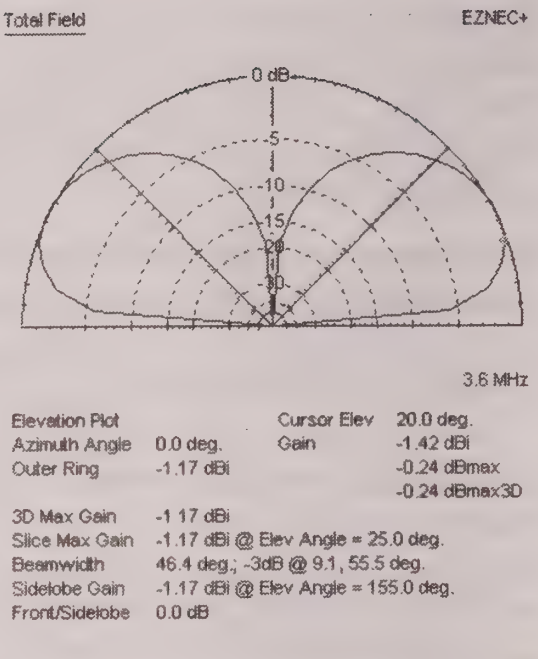


Figure 70 Vertical antenna with 16 radials 0.1 wavelength in length

Such a radial system is far too elaborate for a typical *Buddipole* setup. And, comparisons between the performance of this configuration (with the 16 radials) and a much simplified radial system of four elevated radials shows that all this work does reduce losses—resulting in a nearly 3 dB increase in power (double!), but making the antenna system even more difficult to match because of its very low feedpoint impedance as illustrated in Figure 71.



SWR for 80m antenna with 16 radials 0.1 wavelength in length



Far field plot for 80m antenna with 16 radials

Figure 71 SWR and far field plots for 80m vertical with 16 radials 0.1 wavelength

The tradeoffs to be made with low band antennas are efficiency vs. ease of setup vs. ease of matching the antenna to the transceiver. These tradeoffs can be explored in the SWR plots, far field plots, and configuration information for both the vertical element and radials provided in the *cookbook* section of this chapter.

All configurations in this chapter require the *Low Band Coil* and *Triple Ratio Switch Balun* (TRSB) from *Buddipole,* Inc. The coil tap, TRSB settings, and radial lengths are indicated for each configuration.

Finally, all configuration data such as coil tap selections are approximate. Ground conductivity, terrain, location of nearby objects, and other factors can affect the feedpoint impedance of the antenna. Use the tap information as a starting point. A useful technique for selecting the proper tap is to "slide" the wander lead along the coil and listen for maximum noise from the radio. Figure 44 in the *Buddistick* chapter contains a quick explanation of this technique.

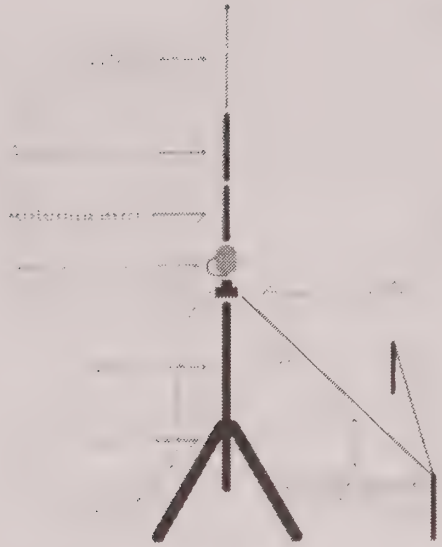
Buddipole Low Band Antenna Cookbook

80m

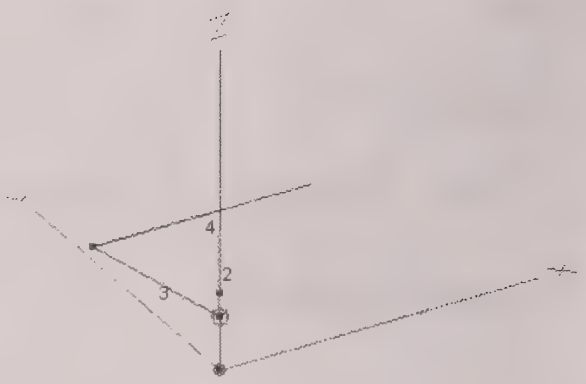
We begin with the 80m band, the most difficult band to configure effectively.

Standard	Vertical element
Buddipole	5.5' whip: 6 sections (all out)
with low	Two antenna accessory arm
band coil	Low band coil: tap 18
TRSB	
	TRSB set to 2:1

The basic configuration using standard *Buddipole* components (plus the *Low Band Coil*) is described in the *Buddipole Low Band Vertical* data sheet from *Buddipole,* Inc. The radial for this antenna is a single wire dropped from the feedpoint at eight feet to a point two feet off the ground 33 feet away. The wire is then bent 90 degrees and run another 33 feet. Figure 72 illustrates this arrangement.



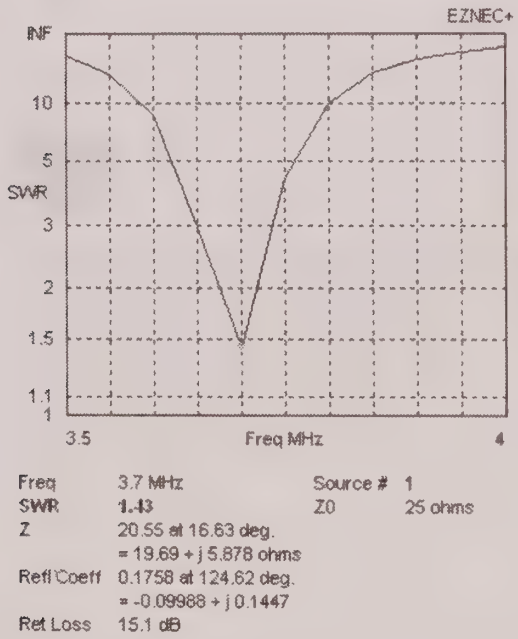
Antenna setup from *Buddipole Low Band Vertical* data sheet



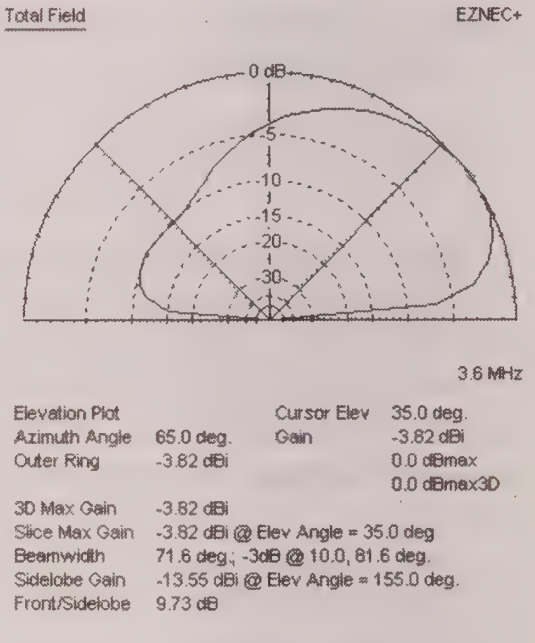
Antenna deployment EZNEC+ modeling software

Figure 72 Single radial for the 80m vertical

The resulting SWR and far field plot for this antenna is shown below.



SWR plot for 80m vertical

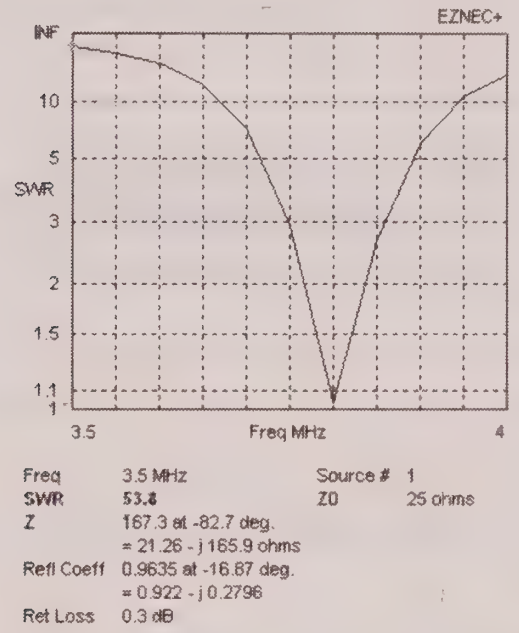


Far field plot for 80m vertical

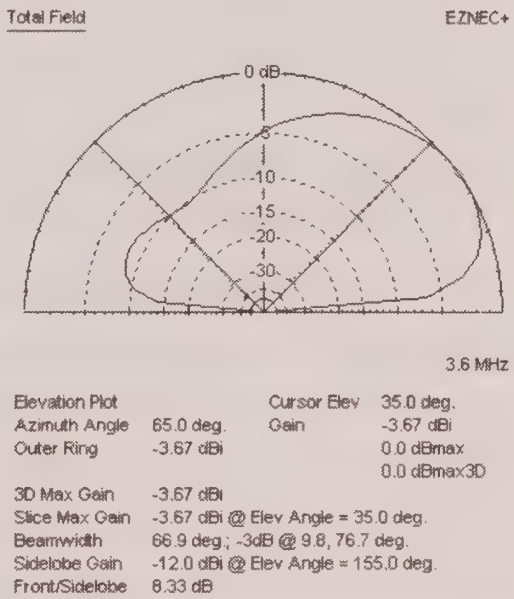
This antenna configuration has about 90 kHz 3:1 SWR bandwidth. Note the gain is -3.82 dBi. That is, at its best the antenna puts energy out at less than the half the power of an isotrophic radiator.

Standard	Vertical element
Buddipole	9.5 foot whip: 6 sections (all out)
with low	Four antenna accessory arm
band coil	Low band coil: tap 16
TRSB	
	TRSB set to 2:1

Increasing the radiator length significantly has no impact on gain, but increases the 3:1 SWR bandwidth to about 120 kHz.



SWR plot for 80m vertical

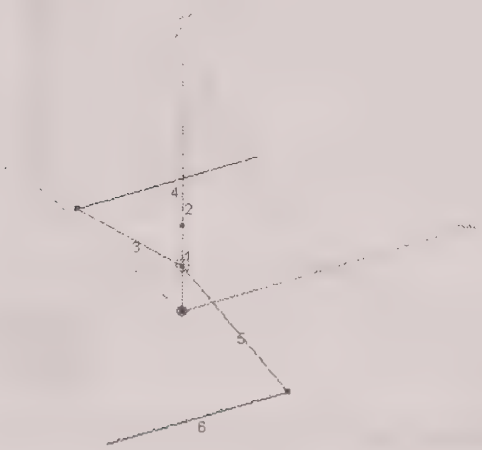


Far field plot for 80m vertical

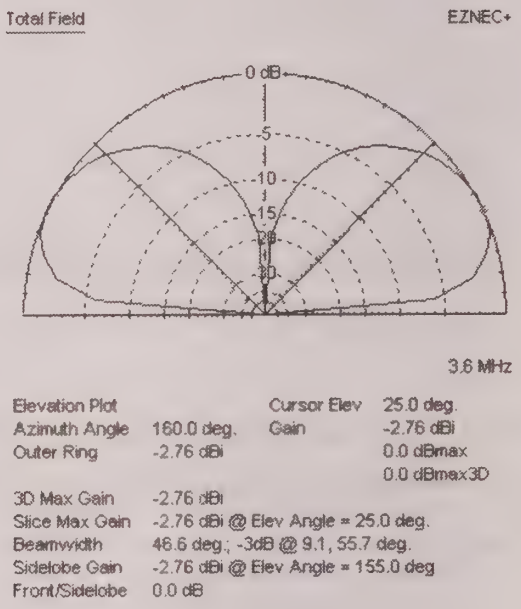
Figure 73 SWR and far field plot for the 80m vertical with long radiator

Adding a second radial to the system increases the gain slightly, from -3.67 dBi to -2.76 dBi. Keeping this in perspective, these gains are very, very small, and the resulting gain from the antenna is still very poor compared to high band antennas. The difference between the 1 radial

system and the 2 radial system is in the shape of the antenna pattern. The second radial reduces the "deafness" on the left side of the far field pattern compared to the single radial version. The second radial evens out the pattern for this low band antenna just as a second radial evens out the patterns of high band antennas. Again, the second radial is not to increase overall gain; the second radial eliminates areas of deafness in the antenna pattern.



Two bent radials for 80m vertical

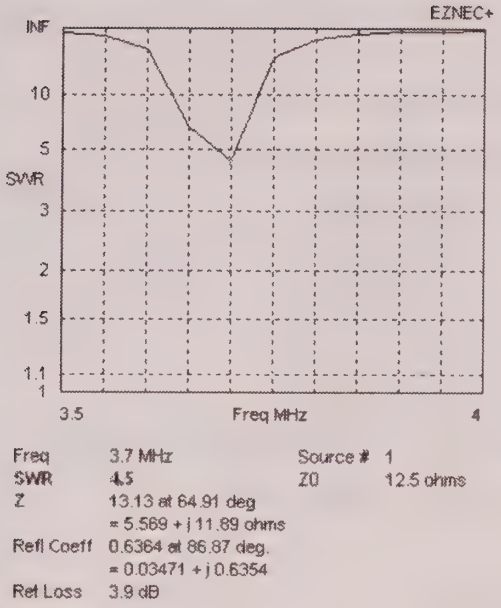


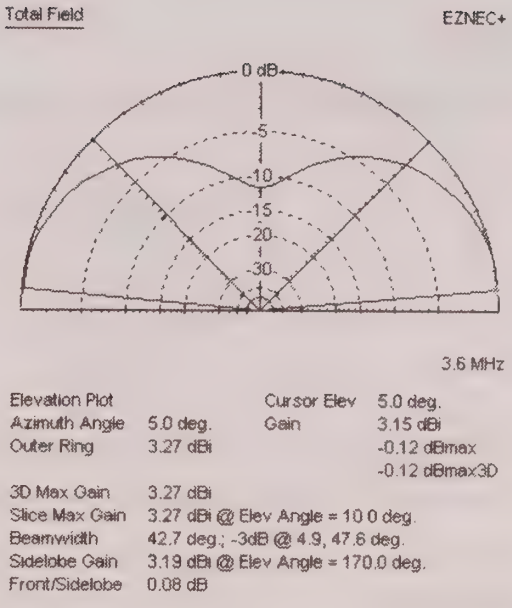
Far field plot for 80m vertical with two bent radials

Figure 74 80m vertical with second radial

What happens if we pick this antenna up and move it to the sea? Since most of the losses are because of the poor ground, the antenna deployed by the saltwater has significant gain compared to the one over the "average" ground. The gain jumps from -2.76 dBi to 3.15 dBi, an increase of 6 dB—a full S unit! Figure 75 has the SWR and far field plot for the antenna deployed over saltwater.

If we can find a way to match the very low feedpoint impedance to the radio's expected 50 ohms then the antenna should perform very well. Unfortunately, making such a match without inducing additional losses is very difficult.





SWR plot for 80m vertical **Far field plot for 80m vertical**

Figure 75 SWR and far field plot for 80m vertical over saltwater

The very low feedpoint impedance (4-6 ohms) is far below the 12.5 ohms the TRSB with the setting 4:1 would match. Still, it is better to have the significant ground losses eliminated and have this matching problem than to lose the vast majority of the power because of the high resistance of the ground. The idea for these low band verticals is to create an antenna system with as few losses as possible, then match them. If a transmatch (antenna tuner) is used, it can supply further transformative matching (2:1, 4:1, etc.), null out remaining reactance, or both.

60m

The 60m band consists of five channels as shown below:

Channel Center	Amateur Tuning Frequency
5332 kHz	5330.5 kHz
5348 kHz	5346.5 kHz
5368 kHz	5366.5 kHz
5373 kHz	5371.5 kHz
5405 kHz	5403.5 kHz

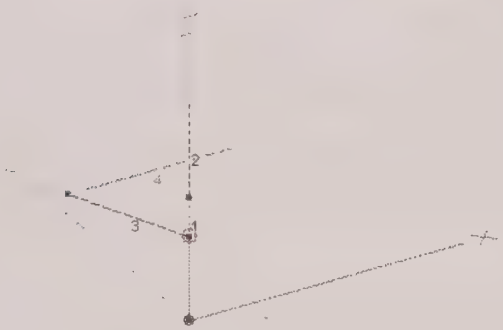
The antenna can be constructed from standard *Buddipole* components plus the *Low Band Coil* and *Triple Ratio Switch Balun* (TRSB).

Standard *Buddipole* with low band coil TRSB

Vertical element
5.5' whip: 6 sections (all out)
Two antenna accessory arm
Low band coil: tap 15

TRSB set to 4:1

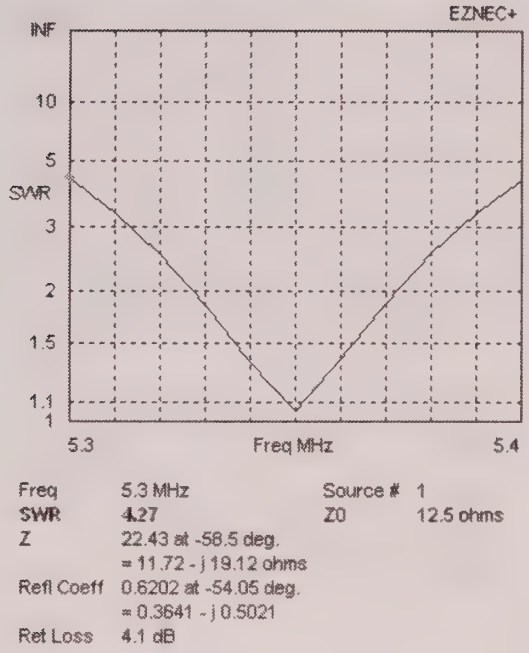
The radial system for this antenna can be a simple one wire bent 90 degrees, though multiple radials are preferred. The antenna and radial layout are illustrated below.



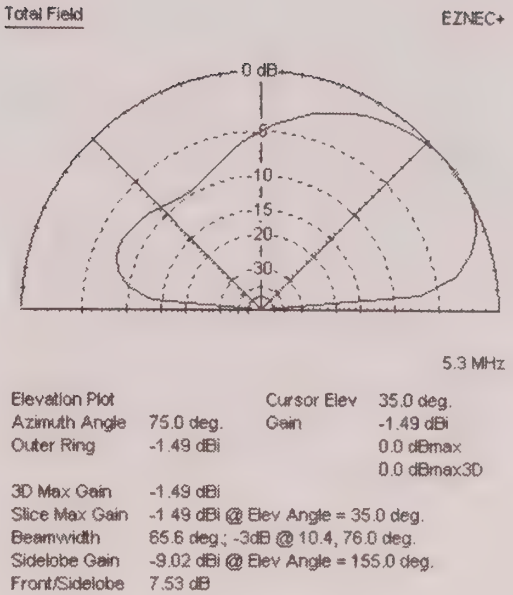
The radial descends from the feedpoint at 8 feet to a point 20 feet away and 2 feet above ground. The radial is then turned 90 degrees and extends another 190 inches (15 feet 10 inches).

Figure 76 Radial deployment for 60m vertical

The antenna is tuned to resonance by extending or reducing the end of the folded radial.



SWR plot for 60m vertical



Far field plot for 60m vertical

Figure 77 SWR and far field plot for 60m vertical (5.5' whip) over average ground

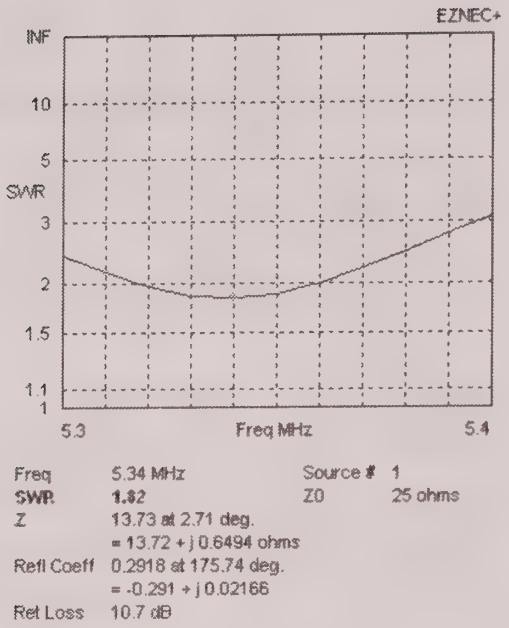
The 2:1 SWR bandwidth for this antenna is very small. Substituting the longer 9.5 foot whip for the 5.5 foot whip smoothes the SWR curve.

Standard Vertical element
Buddipole 9.5' whip: 5+ sections (9 foot 2 inches)
with low Two antenna accessory arm
band coil Low band coil: tap 13
TRSB

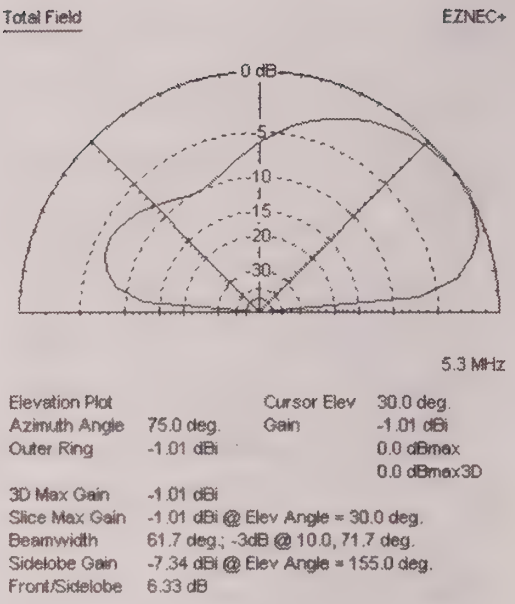
TRSB set to 2:1

9.5' whip

This antenna configuration produces the following results including a 3:1 SWR bandwidth across all five channels.



SWR plot for 60m vertical



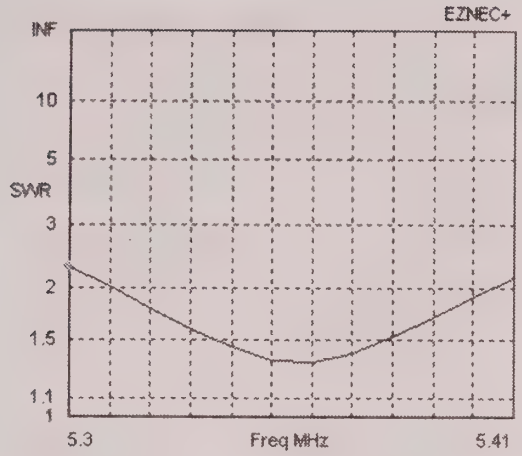
Far field plot for 60m vertical

Figure 78 SWR and far field plot for 60m vertical (9.5' whip) over average ground

A second radial deployed on the opposite side of the first similar to the geometry of Figure 74 evens the far field pattern, reducing "deafness" on the left side of the far field plot.

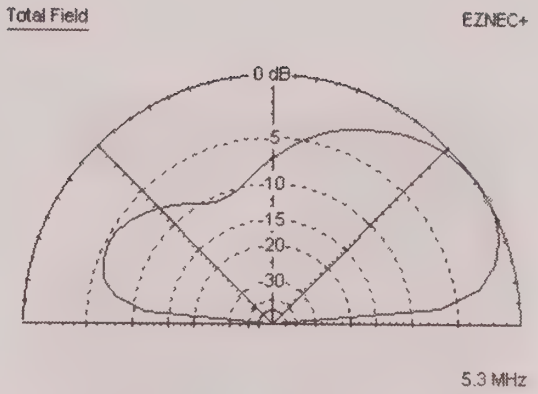
Standard	Vertical element
Buddipole	9.5 foot whip: 6 sections (all out)
with low	Four antenna accessory arm
band coil	Low band coil: tap 12
TRSB	
	TRSB set to 2:1
9.5' whip	
4 arms	

The longest vertical configuration has the following expected performance.



Freq	5.3 MHz	Source #	1
SWR	2.27	Z0	25 ohms
Z	25.12 at -42.49 deg.		
	= 18.52 - j 16.97 ohms		
Refl Coeff	0.3888 at -89.6 deg.		
	= 0.00271 - j 0.3888		
Ret Loss	8.2 dB		

SWR plot for 60m vertical

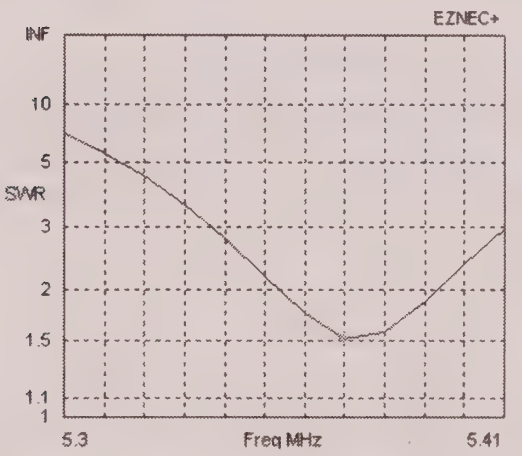


Elevation Plot		Cursor Elev	30.0 deg.
Azimuth Angle	70.0 deg.	Gain	-1.11 dBi
Outer Ring	-1.11 dBi		0.0 dBmax
			0.0 dBmax3D
3D Max Gain	-1.11 dBi		
Slice Max Gain	-1.11 dBi @ Elev Angle = 30.0 deg.		
Beamwidth	58.4 deg.; -3dB @ 9.9, 68.3 deg.		
Sidelobe Gain	-6.52 dBi @ Elev Angle = 155.0 deg.		
Front/Sidelobe	5.41 dB		

Far field plot for 60m vertical

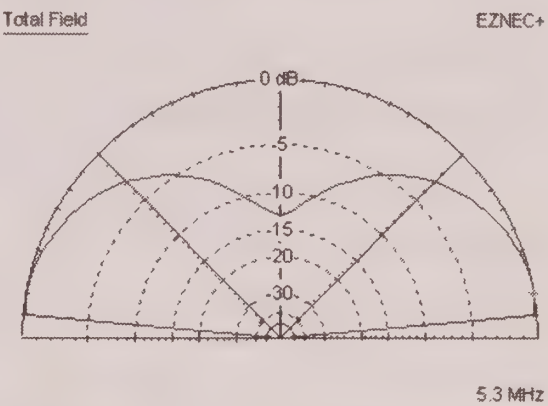
Figure 79 SWR and far field plot for 60m vertical (longest) over average ground

Deploying this antenna on a beach next to saltwater significantly reduces losses, increasing antenna efficiency, but the result is an antenna more difficult to match to the 50 ohms expected by the radio.



Freq	5.37 MHz	Source #	1
SWR	1.52	Z0	12.5 ohms
Z	8.368 at -6.1 deg.		
	= 8.321 - j 0.8885 ohms		
Refl Coeff	0.205 at -165.55 deg.		
	= -0.1985 - j 0.05115		
Ret Loss	13.8 dB		

SWR plot for 60m vertical



Elevation Plot		Cursor Elev	10.0 deg.
Azimuth Angle	5.0 deg.	Gain	4.53 dBi
Outer Ring	4.53 dBi		0.0 dBmax
			0.0 dBmax3D
3D Max Gain	4.53 dBi		
Slice Max Gain	4.53 dBi @ Elev Angle = 10.0 deg.		
Beamwidth	41.2 deg.; -3dB @ 4.9, 46.1 deg.		
Sidelobe Gain	4.49 dBi @ Elev Angle = 170.0 deg.		
Front/Sidelobe	0.04 dB		

Far field plot for 60m vertical

Figure 80 SWR and far field plot for 60m vertical by saltwater

11 Final words

Please allow me to write this last bit in the book in the first person. I have been a *Buddipole* user for a long time, and have used it in a wide variety of situations. I confess one of the main reasons for writing this book was I needed it! I wanted a single place for all my notes, my graphs, and my thinking on the tradeoffs and decisions I have made through all my trials in the field. I hope all this has helped you, too.

The author operating on VP2M

Buddipole, Inc. offers a wide range of products, but the most beautiful thing about them is they are all comprised of standard sized, interchangeable parts that work together, and in combination, to create larger and more efficient antennas. Further, many of these parts are available in the *Buddipole* accessory store so you can add items to your kit as you need them. As you may have guessed by the wide variety of configurations described in this book, I have visited the accessories store on more than one occasion!

Buddipole essential add-ons

- Two extra arms
- Two 9.5 foot whips
- TRSB

Once you have mastered the basic system you have purchased, whether it is the *Buddipole* or *Buddistick*, you should consider the next steps. For example, substituting longer 9.5 foot whips for the standard 5.5 foot whips, will provide a significant boost to most antenna configurations. The addition of two extra arms similarly provides many more deployment options over the standard kit. Finally, the *Triple Ratio Switch Balun* is a key component to most configurations, especially shortened antennas. I consider these components essential to any serious *Buddipole* user. To see the benefits of these simple additions, review the configurations in the previous chapters and see how many more configurations are possible, and how much better these extended configurations perform.

I enjoy traveling with my radio gear and operating from far-away places. I call my efforts *The 100 Pound DXpedition* and on these trips I try to limit the baggage to 100 pounds per person. That is not very much! But, as artists say, "form is freeing." Once the limit was in place it helped me

focus on what was important, and what gave me the best performance per pound. On each of my trips, I have carried at least one *Buddipole*.

I have refined my approach over time. I have begun substituting the standard *Buddipole* tripod and mast for the new *shock-cord masts* offered by *Buddipole*, Inc. These new masts are lightweight, and they collapse to a length suitable for a small backpack. The combined weight of the *Mini-Buddipole* and one of these *shock-cord masts* is only about 4 pounds. Toss in the *Mast Guying Kit* (only a few more ounces) and you have a complete, portable, and effective antenna system.

I should add that the *Mini-Buddipole* systems I carry also have a radial wire kit of my own making, with four wires wound on small kite winders. All four wires are crimped into a single ring connector. The secret to keeping this light and small is my selection of wire. I use #534 wire from *The Wire Man* (http://www.thewireman.com). This is 28 AWG copper clad steel wire weighing less than 1 pound per 1000 feet. That is light! Each radial wire is about 40 feet in length accommodating any band 10m-40m using the vertical configurations described in the *Ground Mounted Verticals* and *Buddipole on the Beach* chapters. The wire is not cheap but it is nearly indestructible and a radial wire assembly made from it should last a lifetime. Be sure you have at least one *Counterpoise Wire Adapter* in your kit so you can connect these radials.

There are two other items you should buy and throw in your kit. The first is a bag of extra coil clips. The clips are strong. I have never broken one. But, I have lost several while assembling or disassembling antennas in the dark. Having a few extras can save an outing. The second item is the *Center Tee Adapter* that provides a means of mounting a *Buddipole* VersaTee onto a standard painter's pole. I stow one of these adapters in each of my kits. It has come in handy more times than I can count.

It was mentioned earlier in the book but it bears repeating: always guy or otherwise cable your *Buddipole*. The *Buddipole* is an extremely rugged antenna but it can be damaged if the system is blown over by a gust of wind. Also, deploying an antenna from a balcony, rooftop, or other high place can have significant advantages over deployments on the ground but there is also a danger of the system, or a piece of it, falling and possibly injuring or killing someone below. Please take care when erecting the system to keep yourself, your antenna, and others safe.

The selection of other optional accessories for the *Buddipole* system will depend upon the kind of operating you do. If you operate on the lower bands (40m-80m) then you should investigate the *Low Band Coil* option. Do you operate from balconies or rooftops? The 16 foot mast would be helpful. Again, one of the great things about the *Buddipole* products is they build on each other to support bigger and more effective configurations.

Finally, consider one of the other benefits of the *Buddipole* design: its use of standards. The threading on the VersaTee, accessory antenna arms, and whips are standard sizes so offerings from other manufacturers can work with the *Buddipole* system to achieve the antenna configuration your deployment requires.

The creation of this book has been a labor of love for me. I wanted a single place where all of my deployment ideas could be viewed side-by-side, all my tradeoff decisions could be scrutinized, and configuration options compared. While no one work could capture all the possibilities the *Buddipole* provides, this book has captured enough that you should be able to meet any deployment challenge with at least one good option.

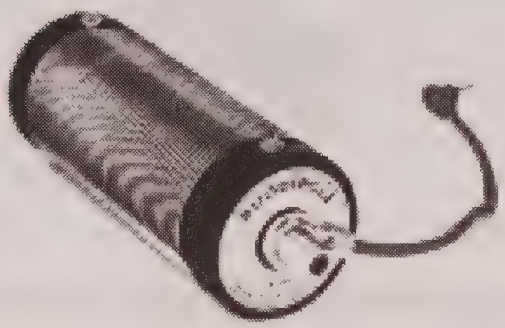
As I write this I am also preparing for another *DXpedition* and, of course, a couple *Buddipoles* will be packed for the trip. Whether it is from the beach, hilltop, or roof of the villa, I know that the *Buddipole* will give me good options for an effective antenna. I hope to work all of you on the air *Buddipole to Buddipole* soon!

B. Scott Andersen, NE1RD

March 2010

Appendix A

Standard *Buddipole* Coil Inductances

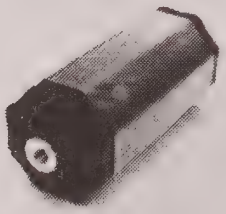


Turn	µH	Turn	µH
1	0.1	21	10.2
2	0.3	22	10.8
3	0.6	23	11.5
4	0.9	24	12.1
5	1.3	25	12.7
6	1.7	26	13.4
7	2.2	27	14.0
8	2.7	28	14.7
9	3.2	29	15.3
10	3.7	30	15.9
11	4.3	31	16.6
12	4.8	32	17.2
13	5.4	33	17.9
14	6.0	34	18.5
15	6.6	35	19.2
16	7.2	36	19.8
17	7.8	37	20.5
18	8.4	38	21.1
19	9.0	39	21.8
20	9.6	40	22.4

Values in the table are approximate.

Appendix B

Buddipole Low Band Coil Inductances



Turn	µH	Turn	µH
1	~0.0	27	22
2	0.1	28	23
3	0.3	29	25
4	0.5	30	27
5	0.7	31	29
6	1.1	32	31
7	1.5	33	33
8	1.9	34	35
9	2.4	35	37
10	3.0	36	39
11	3.6	37	41
12	4.3	38	43
13	5.1	39	45
14	5.9	40	48
15	6.7	41	50
16	7.7	42	53
17	8.6	43	55
18	9.7	44	58
19	11	45	61
20	12	46	63
21	13	47	66
22	14	48	69
23	16	49	72
24	17	50	75
25	19	51	78
26	20	52	81

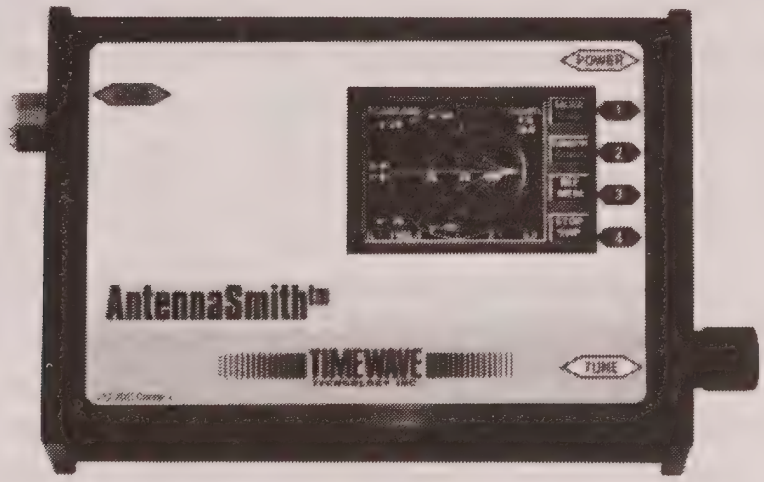
Values in the table are approximate.

Appendix C

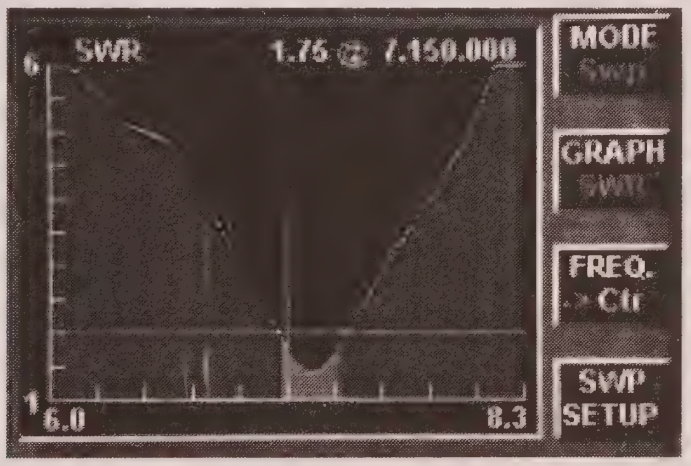
Tools used to assist in the antenna analysis

Modeling was done with EZNEC+ version 5.0 by Roy W. Lewallen. Version 5.0.7 of EZNEC+ was used for all modeling work. More information about this product is available from http://www.eznec.com

Direct measurements of some antenna configurations were performed with the AntennaSmith by Time Wave Technology, Inc. http://timewave.com



This device not only measures SWR and other characteristics of an antenna system but also provides plots of this data.



SWR plot on AntennaSmith

Software accompanying the unit provides for the upload of data and plots to a PC. Some of these plots have been included in the text.

Appendix D

NCDXF beacon transmit times

Call	Location	14.1	18.11	21.15	24.93	28.2
4U1UN	UN, New York	0:00	0:10	0:20	0:30	0:40
VE8AT	Canada	0:10	0:20	0:30	0:40	0:50
W6WX	United States	0:20	0:30	0:40	0:50	1:00
KH6WO	Hawaii	0:30	0:40	0:50	1:00	1:10
ZL6B	New Zealand	0:40	0:50	1:00	1:10	1:20
VK6RBP	Australia	0:50	1:00	1:10	1:20	1:30
JA2IGY	Japan	1:00	1:10	1:20	1:30	1:40
RR9O	Russia	1:10	1:20	1:30	1:40	1:50
VR2B	Hong Kong	1:20	1:30	1:40	1:50	2:00
4S7B	Sri Lanka	1:30	1:40	1:50	2:00	2:10
ZS6DN	South Africa	1:40	1:50	2:00	2:10	2:20
5Z4B	Kenya	1:50	2:00	2:10	2:20	2:30
4X6TU	Israel	2:00	2:10	2:20	2:30	2:40
OH2B	Finland	2:10	2:20	2:30	2:40	2:50
CS3B	Madeira	2:20	2:30	2:40	2:50	0:00
LU4AA	Argentina	2:30	2:40	2:50	0:00	0:10
OA4B	Peru	2:40	2:50	0:00	0:10	0:20
YV5B	Venezuela	2:50	0:00	0:10	0:20	0:30

Table 12 Northern California DX Foundation beacon network schedule

The beacons make one complete cycle on each band every three minutes.

APPENDIX E

Radiation resistance of vertical antennas

When evaluating vertical antenna systems the amount of radiation resistance expected from the system can be computed from the antenna length. The main text has examples for a 40m vertical but any HF antenna can be evaluated by computing the antenna length *angle* as a function of wavelength size, and then referencing the plot below. First, compute the antenna length angle as a function of wavelength:

Length as angle = (length of radiator / whole wavelength size) * 360

For example, a 33 foot radiator for a vertical antenna for 7.1 MHz would be (noting the size of the wave for 7.1 MHz is actually 42 meters):

(33 feet / (42m * 3.28 ft/m)) * 360 degrees = 86 degrees

Here is another example: a radiator that is 110 inches (two arms and a short (5.5') whip used for a radiator in a 15m antenna would be (once we convert everything to inches):

(110 in / (14.2m * 3.28 ft/m * 12 in/ft)) * 360 degrees = 70 degrees

Examining Figure 81 one can see that the radiation resistance presented by an antenna 70 degrees in length is about 19 ohms (or about half of that presented by a full-sized element).

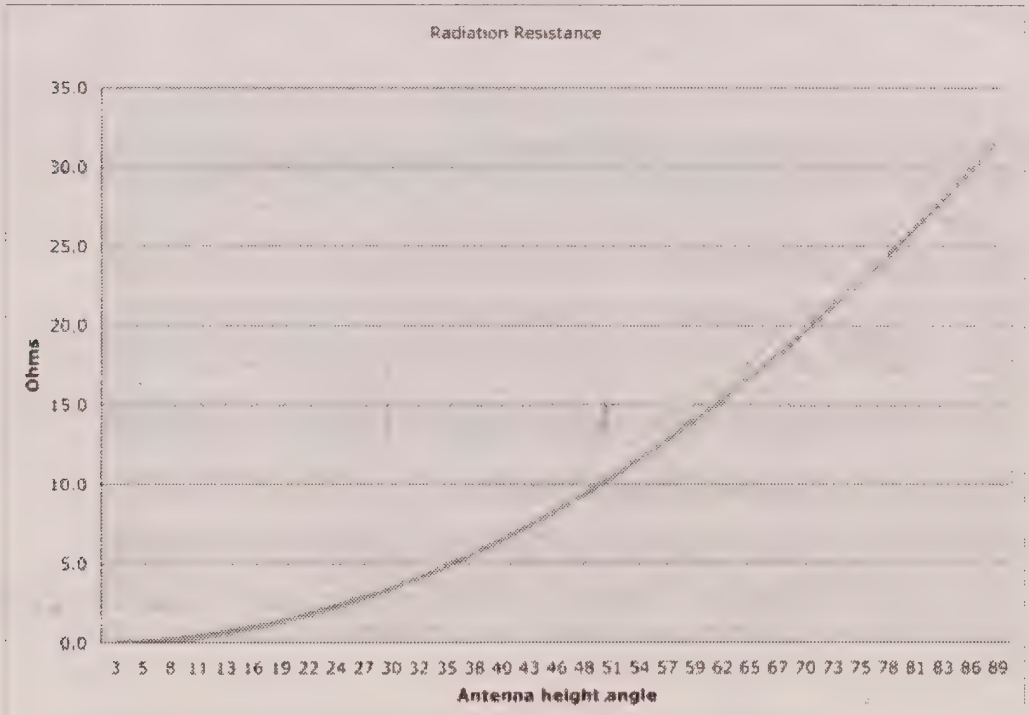


Figure 81 Radiation resistance as a function of antenna length angle

List of terms

BNC	Connector type
BUG	*Buddipole User Group* on Yahoo! http://www.yahoo.com/group/Buddipole
CC	Creative Commons, http://www.creativecommons.org
CWA	Counterpoise Wire Adapter, accessory from *Buddipole*, Inc.
dB	Decibel, a unit-less measure of relative power
dBi	Decibel, a measure of relative power compared to the power emanated by an isotropic radiator
dBm	Decibel, a measure of relative power compared to a milliwatt
DSP	Digital Signal Processing
DX	Distance communication
EZNEC+	Powerful antenna modeling software by Roy Lewallen, W7EL, http://www.eznec.com/
HF	High Frequency
HOA	Home Owners Association
IT	IT Adapter, accessory from *Buddipole,* Inc.
kHz	Kiloherz (1000 hertz)
μH	Microhenrys (one millionth of a Henry), units of inductance
MHz	Megahertz (1 million hertz)
NCDXF	Northern California DX Foundation, http://www.ncdxf.org/
NPT	National Pipe Thread
NVIS	Near Vertical Incident Skywave, a transmitting technique that intentionally aims power near the zenith
PL-259	Connector type
RAK	Rotating Arm Kit, accessory from *Buddipole*, Inc.
PSK	Phase Shift Keying

PSK-31	A digital mode for radio communications that utilizes Phase Shift Keying
Q-signal	Letter combination starting with Q that has a specific meaning in amateur radio communication
Q	Quality, an electrical measurement for an inductor
QRP	Q-signal usually indicating very low power (<5 watts)
RF	Radio Frequency
S-unit	An indication of power shown on an S-meter of a radio. S-9 corresponds to 50μV
SC	Shockcord, either shockcord whip or shockcord mast, accessories from *Buddipole*, Inc.
SO-239	Connector type
SWR	Standing Wave Ratio
TRSB	Triple Radio Switch Balun, accessory from *Buddipole*, Inc.
UV	Ultraviolet
VHF	Very High Frequency
WARC	World Administrative Radio Conference. Three bands, 12m, 17m, and 30m were allocated to amateur radio use in 1979.
WPM	Words Per Minute

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Additional resources were helpful including:

- Buddipole Yahoo! Group (BUG) http://groups.yahoo.com/group/Buddipole which has almost 5000 members as of the time of publication.

Web links

http://www.ncdxf.org/beacon/beaconschedule.html

http://hflink.com/propagation/ Hourly maps for NVIS

In passing

Many books and articles were referenced during the research for this book. I was in the middle of rereading *The Short Vertical Antenna and Ground Radial* by Jerry Sevick, W2FMI, when news of his death reached me. The loss of Dr. Sevick and L. B. Cebik, W4RNL, in 2008 are keenly felt by those of us with an interest in the study of antennas. I did not know either except through their work—which was exemplary. They will be missed.

B. Scott Andersen, NE1RD, is an avid Buddipole user who enjoys contesting and lightweight DXpeditioning. He holds an Extra class license.

The Buddipole family of antenna products is a terrific toolset for hams erecting antennas for fixed, temporary, or portable operation. This book provides options and insights for how to get the most from any deployment, and how to make intelligent trade-offs for size, weight, antenna height, and other factors. Antenna designs for 80m through 6m are covered with just enough theory to help make good choices. Anyone with a Buddipole or Buddistick system can benefit from this work.

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I have had excellent success on DXpeditions by simply spacing a pair of verticals a quarter wavelength apart and connecting them with a ¾ wavelength (at the frequency of interest) 50 ohm coax. Please note that a length of coax which produces only one electrical 1/4 wave length wont work because its *physical length* in the real world will be less than the ¼ wavelength real world physical length needed to actually connect to the two verticals. The shortest length of coax in the real world that will work for a pair of verticals spaced 1/4 wavelength apart and provide the needed 90 degree phase shift is 3/4 wavelength. This wasn't obvious to me 40 years ago until I actually tried it :-)

In the most simple phased vertical set up wherein the two 1/4 wavelength spaced verticals are excited at one vertical and both verticals are connected together with a 3/4 wavelength coax they will produce a cardioid pattern in one direction along the line formed by the verticals. When the array is fed from the other vertical it will form a cardioid pattern in the opposite direction. If both verticals are fed with equal lengths of coax and the 3/4 wavelength phasing line between the two is disconnected then the array will exhibit a figure of eight pattern with the lobes orthogonal to the direction of the cardioid patterns. This simple setup worked great for me when I was chasing European DX from California on 80M years ago and I was primarily interested in one direction.

http://lists.contesting.com/_towertalk/2006-04/msg00143.html

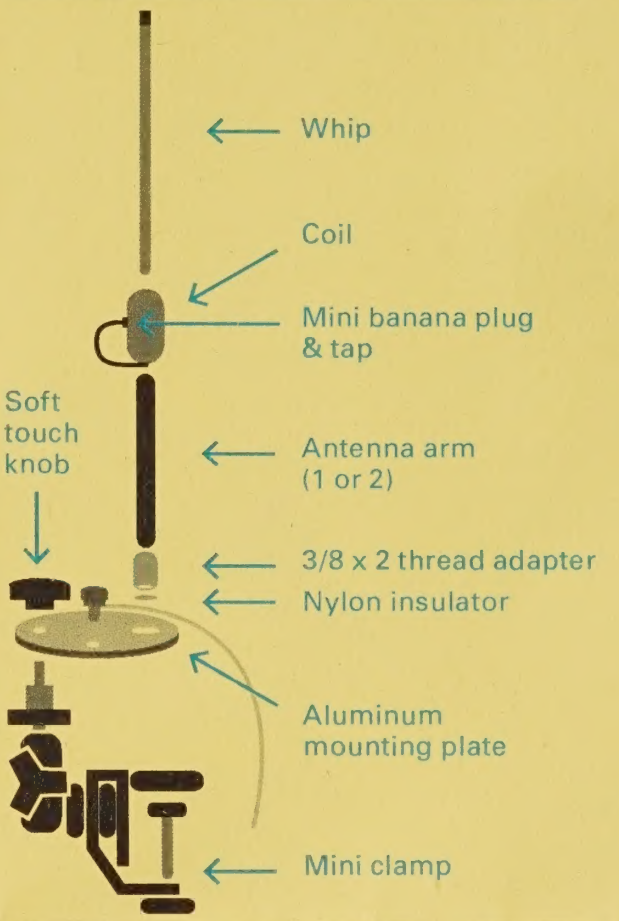
THE BUDDISTICK™ OPERATING MANUAL

Buddistick Tuning Guidelines

Tuning the Buddistick is easy! Thread the two aluminum arms together, and then thread them into the top of the adapter attached to the mounting plate. Thread the coil into the top arm and a telescopic whip into the top of the coil. Pull all the whip sections out fully. Use a good quality coax and connect that coax to the SO-239 which can be found on the bottom of the mounting plate. Use a single radial. The wire we use for the Buddistick is a very high quality Teflon coated silver-plated copper wire. It is wound on a kite linewinder. The linewinder makes it easy to control the wire, and it also becomes the method used for 'tuning' the radial. The wire that is coiled up on the linewinder is not "seen" by the antenna, so when you run out 31 feet of wire, that's what the radial length is.

Try 31' (feet) of wire for 40 Meters, and about 23' of wire on 30 Meters. Start with about 15' on 20 Meters and 10' on 17 Meters. There is a 1/4" ring connector on the wire held by the linewinder. Connect that wire to the 1/4" stud on the mounting plate as shown in the diagram. If you have an antenna analyzer, this is the perfect time to put it to use. If not, follow the instructions below to "tune by ear." *Remember,* you can always add components to the Buddistick to make it longer for more efficiency, and the tuning process is the same in every case.

Buddistick Assembly



Tuning by "Ear"

Connect the coax to your receiver. Set the clamp or mini tripod you are using to hold the Buddistick so that you can reach the coil from your operating position. Turn your radio on, and turn the volume up so you can hear the background noise on the frequency you would like to use. Take the mini-banana plug that is attached to the bottom of the coil and sweep it across the coil with an up and down motion. *Listen carefully,* and you will hear an increase in background noise or signal strength of any stations on frequency. Keep your eye on the coil turn where the strength of the noise or the signal is optimum.

When you find the turn with the strongest signal/noise, place a tap in that position. Then you can check the SWR to see if it's under 2:1. A coil tap up or down or even on the same turn around the coil at one of the other tapping points should give you the right 'sweet spot' so that your radio will put out the full amount of power it is capable of, whether it's five watts or a hundred watts. You may not need any taps on 40 Meters. Just adjust the radial for resonance. If you wish, you can use an antenna tuner to get the SWR down to where your transceiver will like the match. If you get under 2:1 SWR, the chances are pretty good that your rig will put out all the power you need to make contacts.

Remember, you can always adjust that radial by winding a few turns more or by taking a few turns off, thereby changing the length of the wire just a tad. It can make a big difference in tuning. The final tuning of this vertical antenna is a function of the antenna itself and your surroundings and the radial system you deploy. All these factors play a part in matching the antenna. By utilizing the "tune by ear" method you should be able to tune the antenna very quickly in any situation without having to carry an SWR analyzer with you.

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